[ESTABLISHED 1832]
THE OLDEST RAILROAD JOURNAL IN THE WORLD

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY
BY
R. M. VAN ARSDALE, INC.
140 NASSAU STREET, NEW YORK

J. S. BONSALL, Vice-President and General Manager
F. H. THOMPSON, Advertising Manager.

Editors:
E. A. AVERILL. R. H. ROGERS

V. C. JONES, Western Representative
407 Medinah Bldg., Chicago

SEPTEMBER, 1911

SUBSCRIPTIONS—$2.00 a year for the United States and Canada; $2.75 a year to Foreign Countries embraced in the Universal Postal Union.

Remit by Express Money Order, Draft or Post Office Order.

Subscription for this paper will be received and copies kept for sale by
Damrell & Upham, 283 Washington St., Boston, Mass.
R. S. Davis & Co., 346 Fifth Ave., Pittsburgh, Pa.
Post Office News Co., 217 Dearborn St., Chicago, Ill.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
Century News Co., 6 Third St., S. Minneapolis, Minn.
W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.

ADVERTISEMENTS—Nothing will be inserted in this journal for pay, except in the advertising pages. The reading pages will contain only such matter as we consider of interest to our readers.

TO SUBSCRIBERS—The American Engineer and Railroad Journal is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper should at once notify the postmaster at the office of delivery, and in case the paper is not then received this office should be notified, and the missing copy will be supplied.

CONTENTS

VENTILATION

There is no doubt but what the traveling public is becoming each year more demanding in regard to the ventilation and heating of passenger cars, and in view of the policy of the railroads to not only comply with every public demand, but to anticipate it if possible, any information on this subject is, at this time, particularly valuable. The experiments made by Dr. Crowder and reported by him to the American Public Health Association throw considerable new light on the subject and clear up a number of heretofore debatable points. A liberal abstract of his very complete and extensive report will be found on page 369 of this issue.

In considering this report it should be remembered that the results quoted apply only to sleeping cars, and while he concludes that the condition in these cars even without special ventilators is not serious, the same thing would not apply to ordinary coaches where there are from two to three times as many passengers.

The main object of the experiments was to determine if ventilation by exhaustion was a satisfactory method and on this feature the results are very conclusive. The difference in the carbonic acid content of the air in cars fitted with ventilators as compared with those using only open deck sash was very marked and there seems to be no doubt but what if sufficient ventilators of this type are applied to take out the air there can be any desired supply of fresh air for passengers obtained in any type of car.

Dr. Crowder states that he believes, in the case of sleeping cars, the greatest danger to public health is found in overheating and recommends that careful attention be given to the matter of closer control of this feature so that the supply of heat can be quickly adapted to the rapidly changing conditions of a passenger car. While this criticism is more properly applied to sleeping cars than to coaches, it is still worthy of careful attention on the latter, particularly on all steel equipment where the very large radiating surface required for severe weather will quickly result in overheating in ordinary weather unless arranged for close adjustment.

APPRENTICESHIP FOR THE FIREMAN

Apprenticeship courses have been or are being installed on practically all the more progressive railroads and the question of whether they pay or not, at first so frequent, is now seldom heard. There is no doubt in the mind of anyone who has followed the work of the pioneers that they are profitable in a real tangible manner.

This being so in the case of apprentice machinists, boilermakers, etc., what might be expected from an equally serious attempt at training locomotive firemen? These men have it in tneir power to save vast sums in the aggregate if they are properly taught to do it. All companies claim that they train their firemen, and so they do generally in about the same way they formerly trained their apprentices and with about as successful results. Properly trained apprentices have proven their value and firemen trained in a similar serious systematic manner will prove much more valuable.

In a paper on the Railway Fuel Problem before the International Railway Fuel Association, R. Emerson presents some statistics on the cost and possible savings in locomotive fuel which strikingly illustrate the importance of the subject. He states that the cost of railway fuel in this country is equal to a tax of three cents a day, or two per cent. of his wages, for every able-bodied man on the continent. At least twenty per cent. of this can be saved, which would mean the distribution of forty million dollars yearly in dividends—an indirect or direct contribution of over $2.00 to the income of every family in the Union. Mr. Emerson says that while twenty per cent. saving has been assumed, his experience indicates that the introduction of a comprehensive and effective fuel supervision on almost any

[ESTABLISHED 1832]
THE OLDEST RAILROAD JOURNAL IN THE WORLD

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY
BY
R. M. VAN ARSDALE, INC.
140 NASSAU STREET, NEW YORK

J. S. BONSALL, Vice-President and General Manager
F. H. THOMPSON, Advertising Manager.

Editors:
E. A. AVERILL. R. H. ROGERS

V. C. JONES, Western Representative
407 Medinah Bldg., Chicago

SEPTEMBER, 1911

SUBSCRIPTIONS—$2.00 a year for the United States and Canada; $2.75 a year to Foreign Countries embraced in the Universal Postal Union.

Remit by Express Money Order, Draft or Post Office Order.

Subscription for this paper will be received and copies kept for sale by
Damrell & Upham, 283 Washington St., Boston, Mass.
R. S. Davis & Co., 346 Fifth Ave., Pittsburgh, Pa.
Post Office News Co., 217 Dearborn St., Chicago, Ill.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
Century News Co., 6 Third St., S. Minneapolis, Minn.
W. Dawson & Sons, Ltd., Cannon St., Bream's Buildings, London, E. C., England.

ADVERTISEMENTS—Nothing will be inserted in this journal for pay, except in the advertising pages. The reading pages will contain only such matter as we consider of interest to our readers.

TO SUBSCRIBERS—The American Engineer and Railroad Journal is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper should at once notify the postmaster at the office of delivery, and in case the paper is not then received this office should be notified, and the missing copy will be supplied.

CONTENTS

VENTILATION

There is no doubt but what the traveling public is becoming each year more demanding in regard to the ventilation and heating of passenger cars, and in view of the policy of the railroads to not only comply with every public demand, but to anticipate it if possible, any information on this subject is, at this time, particularly valuable. The experiments made by Dr. Crowder and reported by him to the American Public Health Association throw considerable new light on the subject and clear up a number of heretofore debatable points. A liberal abstract of his very complete and extensive report will be found on page 369 of this issue.

In considering this report it should be remembered that the results quoted apply only to sleeping cars, and while he concludes that the condition in these cars even without special ventilators is not serious, the same thing would not apply to ordinary coaches where there are from two to three times as many passengers.

The main object of the experiments was to determine if ventilation by exhaustion was a satisfactory method and on this feature the results are very conclusive. The difference in the carbonic acid content of the air in cars fitted with ventilators as compared with those using only open deck sash was very marked and there seems to be no doubt but what if sufficient ventilators of this type are applied to take out the air there can be any desired supply of fresh air for passengers obtained in any type of car.

Dr. Crowder states that he believes, in the case of sleeping cars, the greatest danger to public health is found in overheating and recommends that careful attention be given to the matter of closer control of this feature so that the supply of heat can be quickly adapted to the rapidly changing conditions of a passenger car. While this criticism is more properly applied to sleeping cars than to coaches, it is still worthy of careful attention on the latter, particularly on all steel equipment where the very large radiating surface required for severe weather will quickly result in overheating in ordinary weather unless arranged for close adjustment.

APPRENTICESHIP FOR THE FIREMAN

Apprenticeship courses have been or are being installed on practically all the more progressive railroads and the question of whether they pay or not, at first so frequent, is now seldom heard. There is no doubt in the mind of anyone who has followed the work of the pioneers that they are profitable in a real tangible manner.

This being so in the case of apprentice machinists, boilermakers, etc., what might be expected from an equally serious attempt at training locomotive firemen? These men have it in tneir power to save vast sums in the aggregate if they are properly taught to do it. All companies claim that they train their firemen, and so they do generally in about the same way they formerly trained their apprentices and with about as successful results. Properly trained apprentices have proven their value and firemen trained in a similar serious systematic manner will prove much more valuable.

In a paper on the Railway Fuel Problem before the International Railway Fuel Association, R. Emerson presents some statistics on the cost and possible savings in locomotive fuel which strikingly illustrate the importance of the subject. He states that the cost of railway fuel in this country is equal to a tax of three cents a day, or two per cent. of his wages, for every able-bodied man on the continent. At least twenty per cent. of this can be saved, which would mean the distribution of forty million dollars yearly in dividends—an indirect or direct contribution of over $2.00 to the income of every family in the Union. Mr. Emerson says that while twenty per cent. saving has been assumed, his experience indicates that the introduction of a comprehensive and effective fuel supervision on almost any

individual railroad will in less than five years result in a reduction of between thirty and forty per cent.

Of this saving it is claimed that nearly one-half can be made by the engine crew. In the necessary instruction to bring the best results, seventy-five per cent. of personal individual practical instruction on the road and twenty-five per cent. of academic or general instruction is recommended. For road instruction one instructor to fifty engines is stated to give good results

Among a number of other very sensible suggestions made by Mr. Emerson is one concerning the fuel furnished the fireman, which, while not new, has been put into practice in very few instances. This relates to screening run-of-mine coal and eliminating all slack, which if no profitable use, such as briquetting, could be found, it will pay to throw away. It is truthfully said that it seems folly to decrease by some five to twenty per cent. the earning power of a train merely for the privilege of making the fireman, already working near his capacity on the larger locomotives, heave through the firedoor a lot of dust of doubtful, if not absolutely useless and deleterious fuel value.

The proper training of firemen would teach them how to fire any grade or quality of fuel to the best advantage and up to the point where physical limitations are reached it would make the practice of screening less important, but where both are done the horse-power of the fireman will reach a figure that will make the present average output ridiculous.

SUPERHEATING AND SMALL LOCOMOTIVES

Over five years ago it was pointed out in these columns that the superheater appeared to offer an excellent opportunity for increasing the capacity of smaller locomotives, so that they might still be retained in a service which had grown too heavy for them in their present condition.

Taking the country as a whole, it is without doubt the local trains that have the greatest difficulty in maintaining their schedule and it is often here that the greatest demand on the locomotives is made for short periods. In an attempt to keep these very important trains on time larger locomotives have been assigned to this service until it is not unusual to see trains which are absurdly unbalanced in their locomotve power. A recent instance noticed which illustrates this feature was a train consisting of a large Pacific type locomotive, which with its tender weighed about 190 tons, and four light cars, a baggage and three coaches, that with their load would hardly total to the weight of the locomotive and tender. That such an arrangement is very uneconomical from a motive power department standpoint is undeniable, and in fact it is open to question if the train was not uneconomical from every standpoint.

There has been so far very little attention given to the superheater in this service, but since its value and economy are becoming every day more assured it would seem about time to investigate the possibilities of keeping the smaller and lighter locomotives with their comparative low cost of maintenance and greater reliability in local service. There has never been a better or more satisfactory locomotive built, up to the limits of their capacity, than the old 10-wheelers, or the American type. Why not see what can be done about raising the limits of the capacity and retaining the many advantages of these locomotives?

SUGGESTION FOR RAILROAD CLUBS

At the last convention of the International Railway General Foremen's Association, through the absence of the reports from two committees and the merging of the third committee's report, there was practically but one subject presented for discussion. Contrary to what might have been expected, this proved to be a most valuable meeting for all in attendance and at no time was there any let-up in the interest or scarcity of speakers. In fact, it was found that five active sessions were not nearly sufficient to exhaust this single subject. It very fortunately happened that the subject of "How Can Shop Foremen Best Promote Efficiency?" was allotted to a committee of one, T. C. Pickard, who gave sufficient time and thought to it to fully develop its phases, which he presented to the members in the form of a series of definite questions. By thus dividing the main subject into its component parts a large amount of time was saved to the meeting and the members spoke directly upon the point under discussion, resulting in meetings of positive value and clear-cut ideas, and covering, so far as the time available permitted, the phases discussed in the very best manner.

It is probable that the members of this Association in attendance would not have received nearly as much help from the convention if there had been eight or ten or even four different primary subjects brought up for discussion as they did from a concentration on this single one. The thought is suggested that some of the railroad clubs could adopt this idea and lay out a schedule at the beginning of the year in which different phases of the same subject would be brought up for discussion at the various meetings during the year, so that at the end of the season the volume of its proceedings would form a thesis of unusual value on the subject selected. If several of the clubs followed the same plan, it would not be long before a library of the various club proceedings would be of the utmost value. Furthermore, railroad men throughout the country who had given special attention to the subject under discussion at any of the various clubs, would undoubtedly make every effort to attend the meetings. Subjects that might be profitably discussed in this manner could include fuel economy, shop design and arrangement, locomotive terminals, organization and many other similar large problems which are capable of clear subdivision.

ASSIST THE COMMITTEES

There was much just complaint at the last railway mechanical conventions over the late receipt of the reports of committees, making it in many cases entirely impossible for a member to become even generally informed on their contents. Such a condition, of course, largely defeats the object of the association particularly so in the case of the Master Mechanics' Association.

In an open discussion of this trouble on the floor, a number of explanations and suggestions were presented which, if remembered and followed out, will probably largely correct the difficulty. It was pointed out that the by-laws of both associations required the submission of all committee reports by April 1, which, if lived up to, would obviate all the trouble. It was explained, however, that in many cases, in spite of all they could do, the committees were not able to get the information required from the members promptly and their reports would be badly delayed from that cause. Then followed the explanation that it often took from 30 to 60 days, or even longer, to obtain the information requested by the committee and the requests were not sent out early enough.

The lesson from the whole discussion seemed to be that the committees should be appointed earlier, should get down to work earlier and that members should not wait for requests for information, but should forward to the committees anything pertaining to their subject which came to their attention.

In accordance with this, the executive committees of both associations have shown their desire to do their share and have already met and selected the committees for next year's work and have sent them out for publication. (See page 375 of this issue.) It is now up to the committees, and especially to the members, to do as well. The subjects to be discussed are now known, the names of the members of the committees are available and it is the duty of every member of the association to promptly notify some one of the committees of anything which he believes they would be interested in. Don't wait for the receipt of a list of specific questions. The committees are entitled to the voluntary assistance of every member and should, in fact must, have it if the best results are to be obtained. If you don't give this assistance you have no right to complain at the lateness of the reports.

AN UNUSUAL TYPE OF FLAT CAR

A very interesting example of a foreign built long flat car has recently been turned out from the works of Usines et Acieries Leonard-Goit, of Marchienne-au-Pont, Belgium, for the North Belgium Railway. In addition to its exceptional length, 83 ft. over buffers, it embodies several distinctive and ingenious features in construction so entirely at variance with American ideas which prevail in the design of long shallow cars that it becomes entitled to more than a passing mention.

Although the car is 79 ft. 4¾ in. over end sills, a most unusual dimension in the practice of any country, it will still be noted that the longitudinal sills are extremely light in appearance, and if the usual construction were followed, would certainly indicate the prospect of an early sagging of serious proportions. These, however, consist of two series of channel section girders placed back to back, each measuring 12¼ x 3⅝ in. The two members composing one girder are held about 2 in. apart by distance pieces at intervals of 4 ft. 11 1/16 in. The two principal girders or longitudinal sills, which are 4 ft. 6¾ in. apart, are firmly braced together by cross braces, placed at intervals of 9 ft. 10⅛ in., the bracing being strengthened by gussets. The battens composing the platform assist in giving transverse strength, and this is claimed, despite the oddity of the general arrangement, to be more than ample for the requirements of the service.

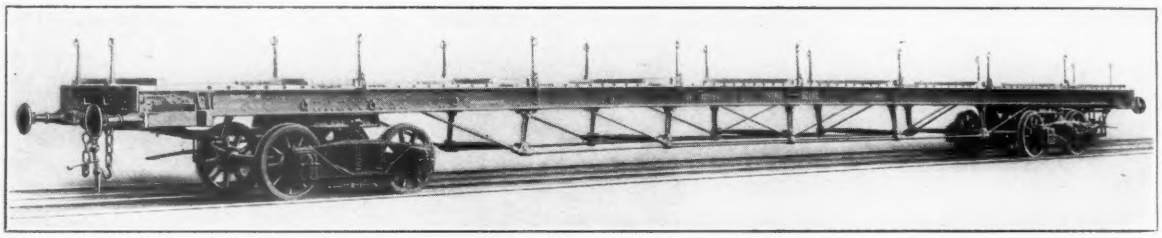
As regards vertical strength the dimensions of the girders given afford no measure of this factor. The girders, in fact, constitute the compression members of a truss, the tension members of which consist solely of a steel wire cable. These latter, in their function as truss rods, constitute the most novel feature in connection with the car. At first glance they would suggest an extremely questionable arrangement for resisting deflection, but a careful examination of the accompanying illustrations will show that the scheme in its assembled entirety embodies a decided factor of strength which is not apparent at a casual examination.

In the car under consideration there are three different strengths of cable employed for the three separate series of bracings. In cars of the same load capacity, but having a length over end sills of 60 ft. 8¾ in., only three struts are used instead of five as shown. The cables have diameters of ¾ in., 1⅜ in., and 1⅝ in., and are constructed on a spiral system. Their tensile strength is 76.2 tons per square inch, so that the resistance to rupture is largely in excess of the usual factor of safety required in ordinary service.

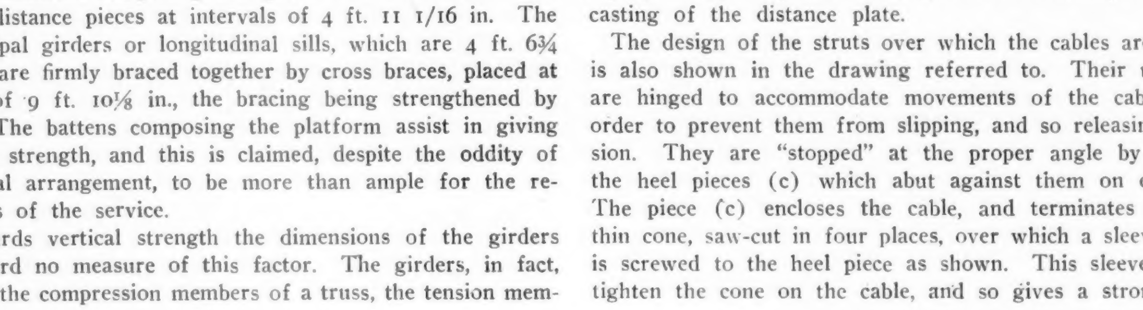
The detail drawings of the arrangement of the struts and the cable "anchorage" show clearly the means employed to firmly secure the latter against any possibility of slip. Each end of the cable is firmly held on its respective platform in a hollow conical piece of steel (a), inside which the cable strands, having been unraveled and twisted back on their ends, are embedded in white metal. This piece (a) is for part of its length cut with a screw thread to engage in a cap (b) which abuts against one of the distance pieces of the longitudinal sills or girders; this distance piece, being bolted between the two members constitutes an effective anchorage for the cable. Any desired strain on the cable is effected by screwing the cap to the left or right, the cable being prevented from twisting with the cap by the square portion of (a), which fits loosely in the upper casting of the distance plate.

The design of the struts over which the cables are stretched is also shown in the drawing referred to. Their upper ends are hinged to accommodate movements of the cable, and in order to prevent them from slipping, and so releasing the tension. They are "stopped" at the proper angle by means of the heel pieces (c) which abut against them on either side. The piece (c) encloses the cable, and terminates in a long thin cone, saw-cut in four places, over which a sleeve fits, and is screwed to the heel piece as shown. This sleeve serves to tighten the cone on the cable, and so gives a strong grip on the latter. Each pair of struts is held together transversely by means of a cast steel cross bar which helps to give rigidity to the whole structure.

Another and practically as important a feature of this car is the system of buffing adopted. It is well known that the use of rolling stock having great variations of length constitutes a source of difficulty and danger when employed indiscriminately on sharp curves, owing to the locking of the buffers, and it is obvious that a car of such exceptional length could not be expected to work safely with one of the usual foreign four-wheel type. Accordingly a system of radial buffers has been introduced as shown in the drawing in plan and section

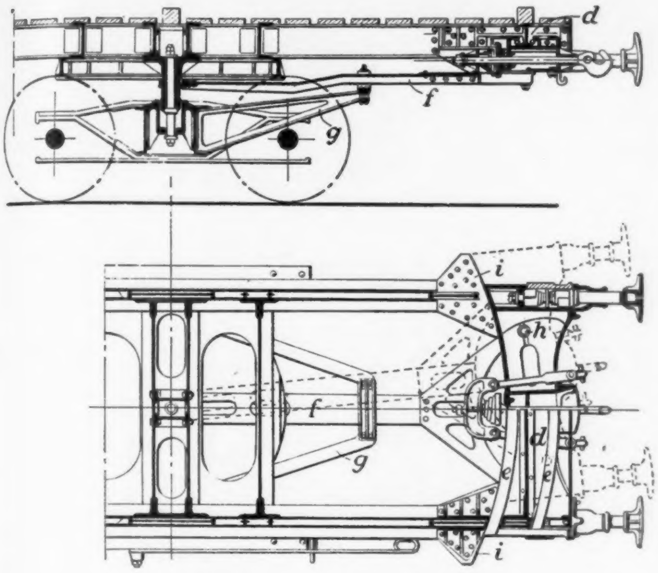


UNUSUALLY LONG FLAT CAR WITH CABLE TRUSSES.



ELEVATION AND PLAN, SHOWING FRAME CONSTRUCTION.

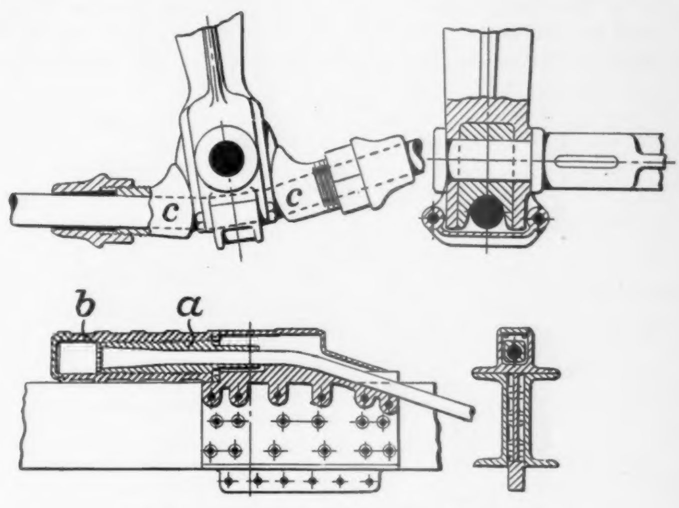
of that part. This construction is as follows: To each end of the truck a slide block (d), made in the form of an arc of a circle, having its center at the center of the truck center pin, is attached by plates riveted to the longitudinal sills A cast steel sector (e), carrying the drawbar and buffing apparatus, rests on this slide block, and bears on it by eight rollers, which assist in reducing friction. The section (e) is controlled by a fork (f) leading from the truck center pin which passes through a guide collar (g) placed at the end of the truck.



ARRANGEMENT OF RADIAL BUFFERS.

Under these conditions, when the car encounters a curve, the truck, guided by its wheels on the rails, pulls with the fork (f), and this by means of the two pins (h) swings the whole buffing apparatus to one side or the other, independently of the car itself. On sharp curves the buffers are swung quite outside the line of longitudinal sills, as shown in the illustration to which reference is made, and in order to support the sills from breakage, cast steel buttresses (i) are bolted to their outside faces

It will be noted in a study of this very interesting car that it embodies an absolute departure in practically all details from accepted ideas in this country, and its unique construction will scarcely carry any particular appeal. Honest workmanship with adequate inspection might attain the ends desired, but a mere casual study of the various features which have been described must convince that the opportunity, or the liability, to turn out poor work is too much in evidence to popularize the design. The weight of this 80,000 lbs. capacity car is only 16 tons, a saving of about six tons as compared with other flat cars of similar capacity, and the claim is advanced that this rather startling method of construction gives far greater strength on the smaller total weight.



DETAILS OF STRUTS AND CABLE ANCHORAGE.

Measurement of Steam Discharge in Locomotive Pop-Valves

RECORD OF ELABORATE TESTS MADE AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY WHICH AFFORD THE MOST COMPLETE AND RELIABLE DATA TO BE GATHERED ON THIS IMPORTANT SUBJECT.

Somewhat over a year ago Edward F. Miller, Professor of Steam Engineering at the Massachusetts Institute of Technology, was commissioned by the Crosby Steam Gage and Valve Co. to undertake an exhaustive test of the steam discharge afforded by the Crosby muffled locomotive pop safety valves. Primarily the object was to determine with absolute certainty how much steam these appliances will discharge, and how they will relieve a boiler and the work was carried on at the Massachusetts Institute because no commercial plant was found where the large steam supply could be uniformly maintained under absolute control.

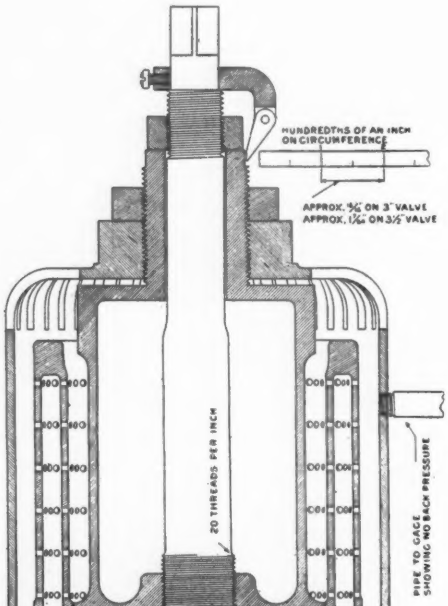
Every precaution that the best engineering experience, skill and foresight could suggest was observed to avoid errors. All the readings and measurements were made by Professor Miller personally, and the results can be accepted with confidence. The report as he has submitted it has been published by the Crosby firm because of its scientific importance and interest to the engineering world. The effect of slight changes of orifice form and proportion in greatly increasing the steam discharge is clearly demonstrated. The report which will repay a careful analysis follows practically in full:

In all of these tests the valves were without springs and were set at a definite distance from their seats and held there rigidly during the tests. In order to avoid unequal expansion, the metal of the valve body and of the spindle was made the same. By reference to the drawing it will be seen that the spring was replaced by a spindle attached rigidly to the valve. This spindle extended through the top of the valve, and carried at its free end a pointer traveling over a graduated cylinder. The lower part of the spindle was threaded near the valve with a 20 thread. The graduated cylinder at the top was divided into five parts, each part representing 1-100 in.

A motion of the pointer of approximately one inch corresponded to 0.01 in. lift of the valve from its seat. Tests on the 3 in. valves were run with lifts set at 0.10, 0.08, 0.05 and 0.02 in. Tests on the 3½ in. valves were run with lifts set at 0.08, 0.05 and 0.02 in. These valves were connected with the boilers through a line of 5 in. pipe, into which two Babcock and Wilcox boilers of 500 boiler horsepower discharged. The 5 in. pipe connected with a 10 foot length of 10 in. pipe, on the end of which was a blank flange 2 in. thick, to which the safety valve was bolted. This flange was bored on the bottom with a hole considerably larger than the inlet to the valve. The entrance edge of this hole was rounded with a curve of one inch radius. On the other side of this blank flange, and enclosing the safety valve, was a 10 in. flanged tee. The outlet of the tee led to the

condenser. The end of the tee on the straight run was covered with a blank flange. Between runs this blank flange on the end of the tee was removed, and the setting of the valve changed. After each run the valve was examined to see if it had moved from its previous setting.

The steam passing through the valve was condensed in a surface condenser which was tested immediately before and immediately after each test for tightness. The condenser was found to be absolutely tight. In every case the outer muffler casing was screwed down to its lowest position. The steam was led from the boiler through a small separator in the boiler room,

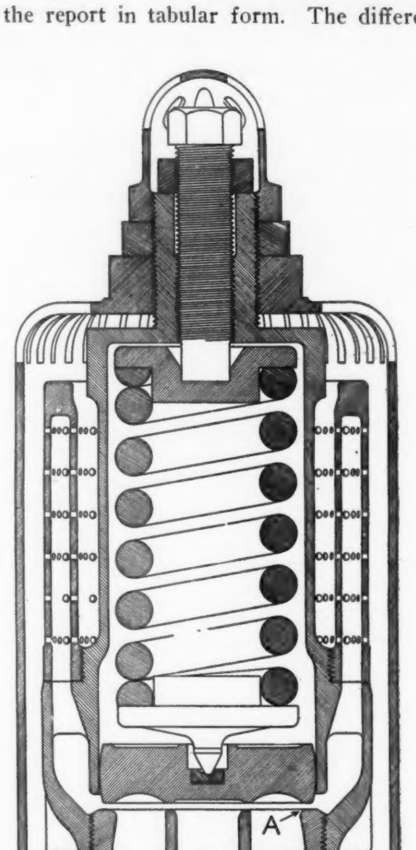


VALVE ARRANGED FOR TEST.

then through a second separator located about 20 ft. from the safety valve. A calorimeter was attached to the 10 in. pipe about 8 ft. from the safety valve, and the quality of the steam determined. In all of the tests the steam was practically dry. To see whether or not there was any pressure in the muffler, a copper pipe was connected and led outside of the 10 in. tee, and a low pressure gage attached. In no case was there any pressure shown by this gage.

The boiler gage used was a Crosby standard test gage attached to the 10 in. pipe. In nearly all of the tests the gage was read at one minute intervals. The pressures given in the tables are the average of five readings. The pressure coming on the valve tends to make the opening through the valve greater than the "lift as set," due to the yielding of the metal. To determine this yielding, the valves were placed in a small Riehle testing machine, and a load equal to the steam pressure on the bottom of the valve applied to the valve. The additional opening due to this yielding was determined by micrometer measurements. The tank weights as taken are given in every case.

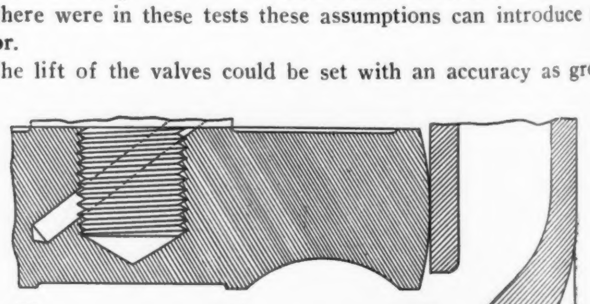
All tests with low lifts were made at least sixty minutes long to minimize any error due to difference of level in the hot well under the condenser. The condensed steam is pumped out of the hot well by a pump operated through a float and valve. A difference of about one inch is required ordinarily to make this float operate. An inch difference in level in the hot well means an error of 9 pounds of water. The different results are appended to the report in tabular form. The different tests on



VALVE SHOWING ROUNDING OF SEAT.

one valve have been reduced to a common pressure by assuming the discharge through a given orifice to be proportional to the absolute boiler pressures. For such small variations in pressure as there were in these tests these assumptions can introduce no error.

The lift of the valves could be set with an accuracy as great



ENLARGED VIEW OF VALVE SEAT.

as that of the 20 thread screw. As the total motion was only 1-10 in., it is probable that the error from this source is not over half a thousandth of an inch. The difference in expansion due to temperature between the body of the valve and the valve and its spindle was obviated in all cases by making these metals the same. Furthermore, in testing the valves, the adjustments and settings were always made while the valves were hot, practically at the temperature of the valves during a test.

The additional lift, due to the yielding of the metal due to the steam pressure on the under side of the valve, was determined in the case of each valve. The movement of the valve with reference to its seat was measured by a micrometer caliper.

Different sets of readings on any valve varied 0.0005 in., and the results are liable to be in error by this amount. It is probable that, considering all of the errors in determining the total lift of the valve, the result is good to about 0.001 in. The condenser in which the steam was condensed was an Alberger bottom inflow surface condenser with hot well at the bottom. Besides the regular drain to the hot well there were additional drains of 4 in. pipe, one from each end of the condenser to the hot well. The level in the hot well varied about one inch, which corresponds to about 9 pounds of steam. Each weighing of a tank empty as a tank full is good to ½ lb. In the runs with 0.008 and 0.10 in. lift, if all errors in weighing are assumed to be cumulative and an error of one inch in the level in the hot well be also considered, the maximum error is 15 lbs. The probable error is less than this, but even this is a small percentage of the total.

In the case of 0.02 in. lift the maximum possible error due to all sources would be 12 lbs., and for the very worst case this is 12 in 2,845, or less than five-tenths of one per cent. The results of the calorimeter tests are good within 2 in the third decimal place. The pressure readings by the boiler gage were taken at one minute intervals during most of the time. Occasionally, when the pressure was varying, these were taken more frequently. The boiler gage was recalibrated and found accurate.

The summary of results accompanying the above valuable report demonstrate conclusively the advantageous effect of slightly rounding the turn to the seat passage in securing a greater volume and weight of steam discharged. This was, however, only to the small extent that the same castings would permit, no changes in the patterns being made for this. Reference to the drawing herewith will illustrate the very light chamfer referred to. In the tabulated summary of tests the valves so treated are designated as "rounded edge," and those with the usual angular corner as "square edge." It may be well to add in connection with these same tables that the letters (J) (O) (A) and (B) have no significance, being stamped upon the valves before the tests simply as a convenient method of identification.

3-INCH CROSBY MUFFLED LOCOMOTIVE POP SAFETY VALVE

FLAT SEAT (ROUNDED EDGE), VALVE MARKED "O"

Lift of valve as set	.02	.05	.08	.10
Total lift, including yielding of metal	.0247	.0547	.0847	.1047
Pounds discharged per hour	3,309	7,250	10,414	12,442
Boiler pressure (gage)	209.0	205.8	201.3	198.3
Pounds discharged per hour, reduced to 200 pounds gage	3,178	7,059	10,352	12,542
Pounds discharged per minute, reduced to 200 pounds gage	52.9	117.7	172.5	209.0

3-INCH CROSBY MUFFLED LOCOMOTIVE POP SAFETY VALVE

FLAT SEAT (SQUARE EDGE), VALVE MARKED "J"

Lift of valve as set	.02	.05	.08	.10
Total lift, including yielding of metal	.0247	.0547	.0847	.1047
Pounds discharged per hour	2,845	6,313	9,342	11,222
Boiler pressure (gage)	208.0	201.0	201.5	201.0
Pounds discharged per hour, reduced to 200 pounds gage	2,743	6,284	9,277	11,170
Pounds discharged per minute, reduced to 200 pounds gage	45.7	104.7	154.6	186.2

3½-INCH CROSBY MUFFLED LOCOMOTIVE POP SAFETY VALVE

FLAT SEAT (ROUNDED EDGE), VALVE MARKED "B"

Lift of valve as set	.02	.05	.08
Total lift, including yielding of metal	.0251	.0551	.0851
Pounds discharged per hour	3,989	8,482	12,172
Boiler pressure (gage)	209.2	202.7	199.5
Pounds discharged per hour, reduced to 200 pounds gage	3,825	8,377	12,201
Pounds discharged per minute, reduced to 200 pounds gage	63.7	139.6	203.4

3½-INCH CROSBY MUFFLED LOCOMOTIVE POP SAFETY VALVE

FLAT SEAT (SQUARE EDGE), VALVE MARKED "A"

Lift of valve as set	.02	.05	.08
Total lift, including yielding of metal	.0251	.0551	.0851
Pounds discharged per hour	3,688	7,688	11,319
Boiler pressure (gage)	212.5	204.2	205.0
Pounds discharged per hour, reduced to 200 pounds gage	3,485	7,541	11,062
Pounds discharged per minute, reduced to 200 pounds gage	58.1	125.7	184.4

As these valves are intended primarily for railroad service, it is of considerable interest to make some calculations to show what these figures mean in discharge capacity as applied to their use on locomotives. Having now further exact determinations of the safety-valve discharge, free from any elements of uncertainty and requiring no estimates of probable performance, it is possible to arrive at fairly reliable results, since the steaming capacity of various locomotives is known to a very satisfactory degree of accuracy.*

Professor Miller found by experiment that it was not practicable to eliminate the effect of the stress of the steam pressure against the face of the disc while the valve was discharging. By careful measurement, as shown in his report, this thrust was determined to be 0.0047 of an inch in the 3-inch valves and 0.0051 of an inch in the 3½-inch valves, and he reckoned the actual seat opening as tnis much more than the apparent lift of the disc indicated on the micrometer spindle. This strain of the parts was thus measurable, even though effort had been made to avoid it by placing the threaded support for the spindle very close to the disc itself.

As the basis for easier comparison, the totals given in the summary tables prepared by Professor Miller to accompany his report have been reduced to the equivalent amounts for exactly 0.08 of an inch lift of the disc from its seat, and for various boiler pressures, especially for convenience in calculating the discharge afforded in case where the valves are used in pairs, set, for example, at 200 lbs. and 205 lbs., or at 180 lbs. and 185 lbs. respectively. If greater or less lift than the recommended 0.08 in. is preferred the amount of the discharge may be calculated from the exact valve seat area, or can be taken as fairly proportional to that given in the tables for the same pressure.

It is well now to consider how much steam discharge may be required for the different types of locomotives, and how Crosby muffled valves would take care of any steaming capacity. At the Master Mechanics' Convention in June, 1910, the Committee on Safety Valves reported that investigations were made by E. D. Nelson, engineer of test, Pennsylvania Railroad, on loco-

* See also AMERICAN ENGINEER, April, 1909, page 162.

motives carrying 200 lbs. gage pressure and having 4,231 sq. ft. of heating surface and 56½ sq. ft. of grate area, and that the maximum steam discharge or evaporation was 2.44 lbs., the minimum 1.18 lbs. and the mean 2.05 lbs. of steam per square foot of heating surface per hour and the committee recommends the following formula providing for safety valve capacity to discharge twice this mean amount, or 4.1 lbs. of steam per hour per square foot of heating surface:*

$$A = \frac{0.08\ H\ S}{P}$$

A = Outlet of valve in square inches.
H S = Boiler heating surface in square feet.
P = Absolute pressure, = gage pressure + 15 lbs.

For a locomotive of the given 4,231 sq. ft. heating surface, this formula would mean safety valves capable of discharging 17,347 lbs. of steam per hour; and it will be seen from the tests that two Crosby 3 in. muffled valves at exactly 0.0847 in. lift discharge 20,704 lbs. of steam per hour at 200 lbs. gage pressure. If one of these valves were set at 200 bs. and the other at 205 lbs. and regulated to lift only 0.08 in., it is found that one valve would discharge 9,872 lbs. and the other 10,102 lbs., or a total of 19,974 lbs. of steam per hour, even with this smaller lift, an amount amply in excess of the total required under the proposed rule.

Professor Miller's test shows that, allowing 4.1 pounds per hour per square foot of heating surface, two of these 3-inch valves at 0.0847 of an inch lift will amply provide for locomotives having heating surface up to 5,050 square feet and two Crosby 3½-inch valves at 0.0851 of an inch lift are sufficient for locomotives having 6,000 square feet of heating surface, if such were to be built. Even if regulated to permit only 0.0547 of an inch lift, the two 3-inch Crosby valves are sufficient for locomotives up to 3,443 square feet of heating surface, if both valves were set at 200 lbs. and advantage were not taken of the greater steam discharge afforded by setting one of them at the higher pressure of 205 lbs., for example. There is also the further assurance derived from past experience that even under the most severe requirements of heavy steaming in freight service on Western mountain railroads, on locomotives that have been equipped with three 3-inch Crosby valves, set only 2 lbs. or 4 lbs. apart, the third valve has never been known to blow.

The Lake Shore and Michigan Southern Railway has, for the past two years, been handling its scrap material by means of a gantry crane and lifting magnet, at a cost of from four to seven cents a ton, or from ten to twelve cents per ton in and out, including sorting. Before the installation of the crane and magnet, in May, 1909, the cost ranged from thirty to thirty-five cents a ton, which is about the usual cost for handling such scrap material by hand with what are considered to be good facilities.

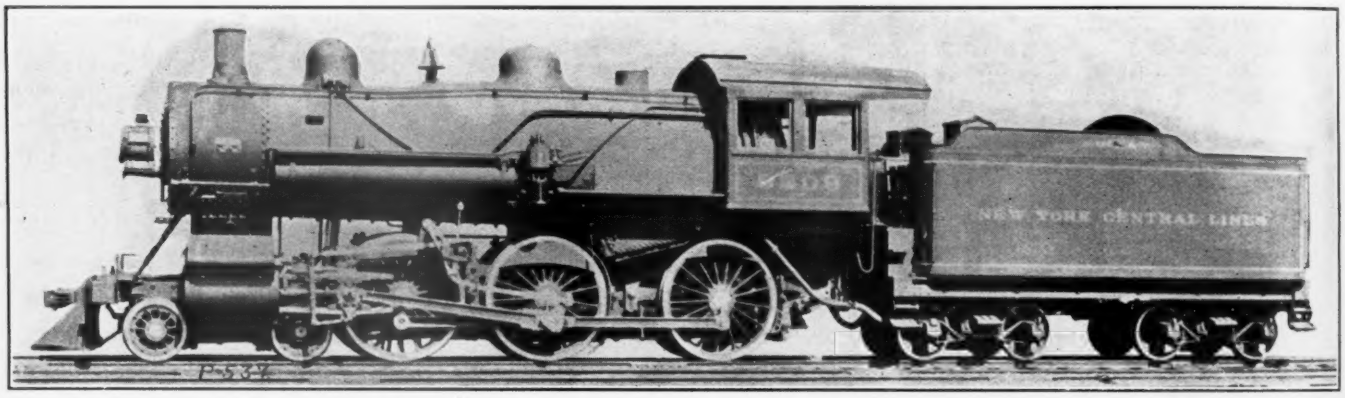
* See American Engineer, Aug., 1910, page 317.

EXPRESS LOCOMOTIVES WITH ALLFREE CYLINDER AND VALVES

PITTSBURGH & LAKE ERIE R. R.

The Pittsburgh & Lake Erie Railroad, one of the New York Central Lines, has had for several years a number of locomotives of different types, equipped with the Allfree system of cylinders and valves, which has been previouslly illustrated and described in this journal.* These engines are of the 2-8-0 freight, 4-4-0 and 4-6-0 passenger types, and have proved so satisfactory that five additional of the 10-wheel type, as herewith illustrated, have recently been completed at the Pittsburg works of the American Locomotive Company.

The requirements of the Lake Erie passenger service are very severe, and locomotives capable of sustaining great power and speed are a necessity. For instance, from Youngstown, O., to Pittsburg, Pa., 65 miles is made in 90 minutes with stops at New Castle Jn., Beaver Falls, Brighton and Beaver, with a minimum weight behind the tender of 300 tons. On frequent occasions this latter rises to 600 tons, and the average train may be set at 400 tons, irrespective of engine and tender. The road has several grades and a number of high degree curves, in addition to points where speed must be reduced. In consequence, besides the requisite of sustained high speed, rapid



ALLFREE TYPE LOCOMOTIVE FOR PITTSBURGH AND LAKE ERIE R. R.

acceleration becomes imperative. In this class of work the Allfree type of 4-6-0 locomotive has proved all that has been claimed for that system, and duplication of the original design becomes fully consistent.

The new lot of locomotives accordingly reproduce the former order, and to still further enhance their efficiency they have been equipped with the Locomotive Superheater Co.'s† standard fire tube superheaters. This latter feature is probably the most interesting detail in connection with this order as it represents the first application of superheat to the Hobart-Allfree valve and cylinder arrangement. A test of these locomotives will no doubt be very closely watched by motive power officials, and inasmuch as the Allfree system has produced very uniform results in fuel economy and in increased hauling capacity, the addition of the superheater, which has been thoroughly tested on the New York Central Lines, should show a very gratifying increase in efficiency.

With these exceptions the new locomotives do not embody any particularly original or novel features. The general design as marked out is very attractive, and may be taken as the best American representative of the 10-wheel type, of which comparatively few have been constructed in recent years.

More Than 1,000,000 Tons of Iron Ore have been shipped from Bell Island Mines, Newfoundland, this year by the Dominion Steel Corporation and the Nova Scotia Steel and Coal Company.

* See Amer. Eng'r., Sept. 1906, p. 334 and Oct., 1910, p. 408.
† 30 Church St., New York, N. Y.

NEW DESIGN THREADING MACHINE

For many years the name Landis has been synonymous with the best and latest practice in threading machines in the minds of master mechanics and shop superintendents. True to this reputation, the Landis Machine Co., Waynesboro, Pa., has recently brought forth several new types of threading machines which possess many unique and valuable features. Three of these shown in the accompanying illustrations demonstrate the success of the efforts of the designers.

Figure 1 shows a ½ in. double head bolt cutting machine in which steel guides instead of cast iron guides, as has been the common practice, are used. The steel guides possess a number of advantages, two being particularly noticeable; they are very accurate to size and possess perfect alignment at all times unless effected by wear after long usage, and when effected by wear they can readily be replaced at a very slight expense; there is no tendency for cuttings to collect on the guides and cause wear. This machine is built with a wide body, with large space for chips, and oil tank in the base separated from chip space by fine screen. The carriage is light yet very strong and easily operated for rapid production. In fact, the whole machine is designed for high speed work and is furnished almost exclusively with high speed steel dies.

In Fig. 2 is shown the new 1 in. high double head bolt thread-

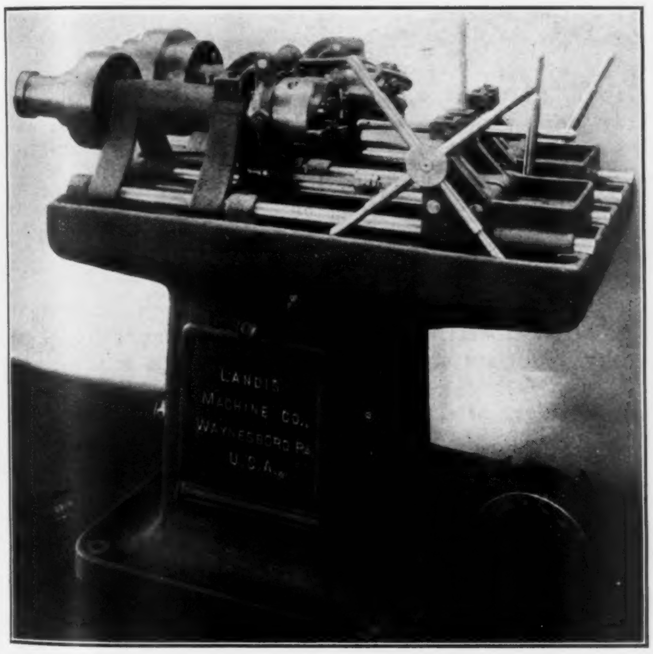


FIG. 1.

ing machine with constant speed motor, silent chain drive, and mechanical speed change device, with a speed range of 3¼ to 1. The motor is mounted on top of the machine out of way of dirt and oil, making the entire equipment very compact and taking up a minimum amount of room. Speed changes can be made while the machine is in operation, and any speed between the maximum and minimum can be acquired quickly. The machine is also adapted for high speed work, and the carriages have adjustment up and down or sidewise for centering to the die, being furnished with either rack and pinion operated carriages or with lever operated carriages.

The other illustration shows the new 1½-in. motor driven double head staybolt cutter with variable speed motor with speed variation of 4 to 1, so that a very wide range of speeds can be had for taking in any work between minimum and maximum, also making it possible to take advantage of using either carbon or higher speed steel dies, as the case may require. On this machine the motor is mounted on top and in direct connected. This machine is furnished with lead screw attachments for one or both heads, as may be desired, and can be arranged to cut any pitch and diameter within the range of the machine by changing gearing, no extra lead screw being required. All the main spindles are provided with recesses to allow the lubricant to return to the oil tank.

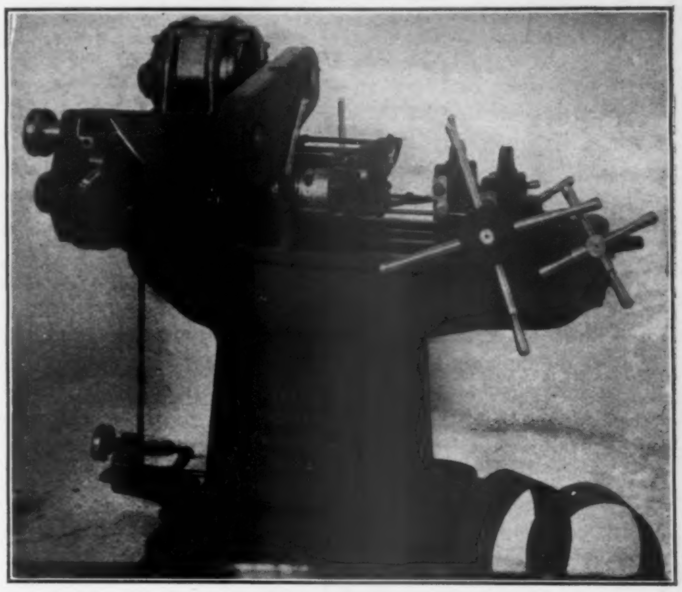


FIG. 2.

On all of these machines the well-known Landis type of die is used and it is held in different manners to suit the different requirements. Two types of chasers can be supplied in this die. In one type the cutter is held by means of a clamp which comes flush with the front edge of the die, so as to admit of cutting close to shoulders or heads of bolts at any time. This is the type of holder used for regular bolt work or for cutting close to shoulders. Dies with very short throats or with no throats at all can be used, and as no grinding is done in the throat of the die when sharpening the throat remains permanent, and this gives a marked advantage on many classes of work.

The other type, known as the mill type, was illustrated on page 376 of the September, 1910, issue of this journal. This clamp is used especially when threading pipe as the clamp comes over the chaser in such a manner as to protect it when the pipe splits or catches the chaser. This clamp is being used in pipe work exclusively on the Landis heads and affords a rigid support

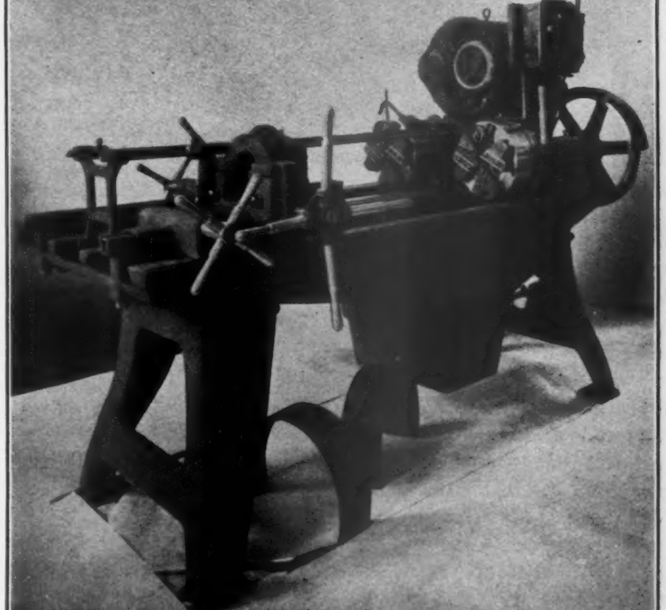


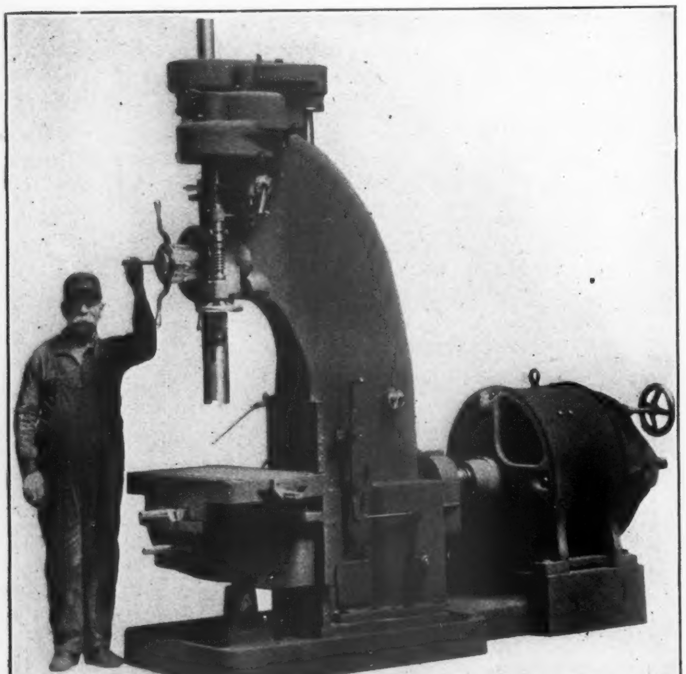
FIG. 3.

to the die. The die holders are made entirely of steel, as are also the die heads on all Landis machines. Any of these machines can be arranged for constant or variable speed motors, as the case may require.

TESTS OF TWIST DRILLS

During the sessions of the recent railway mechanical conventions at Atlantic City the Cleveland Twist Drill Co. gave a demonstration of the quality and work of milled and flattwist drills taken from the regular stock, during which some very remarkable results were obtained in connection with high speed drilling and quantity of material removed.

The demonstration was made on the Foote-Burt No. 25½ high duty drill shown in the illustration. The power and rigidity of this machine are evident from its appearance and the claim of the builders that it has a capacity for high speed drills 3½ in. in diameter in solid steel would not seem to be excessive. In fact these tests proved the quality of the machine as much as it did the drills and the full capacity of neither was reached. The machine has a swing of 36 in. and is driven by a 20-h.p. variable speed motor geared direct through a 2 to 1 reduction. The back gears give a further gear reduction of 2 to 1 and with the variable speeds in the motor the machine has a range of spindle speeds of from 37½ to 600 r. p. m. There are but one set of mitre gears in the whole machine, all others



FOOTE BUST HIGH DUTY DRILL ON. WHICH TESTS WERE MADE.

being spur gears, which are always in mesh, the worm gear feeding arrangement of course excepted. Some of the more important dimensions of this machine are as follows: Center of spindle to face of column, 18 in. Maximum distance nose of spindle to top of table, 31½ in. Length of power feed, 16 in. Diameter and length of spindle sleeve, 4½ by 24¾ in. Width of steel rack, 2 in. Vertical adjustment of table, 18 in. Longitudinal adjustment of compound table, 14 in. Cross adjustment of compound table, 8 in. Compound table reduces maximum distance from nose of spindle to top of table 5¾ in. Net weight of machine, 7,000 lbs.

A record for high speed drilling was made during these tests by a 1¼-in. Paragon flattwist high speed drill, which was forced through cast iron at a rate of 57½ in. per minute, nearly an inch per second, the revolutions being 575 and the feed .10 in. Under these conditions it removed 70.56 cu. in. of cast iron per minute. Even this did not reach the limit of strength of the drill, but could not be exceeded because of the inadequate capacity of the electric wires furnishing current to the motor.

Another noteworthy result was in connection with a 2½-in. milled drill, which drilled 68 holes through a billet of machinery steel 4½ in. thick without being reground. This drill was operated at 150 revolutions per minute with a feed of .015 in. per revolution and removed a total of 1,418 cu. in. of material. It was still in good condition, but the closing of the conventions concluded the tests.

In the following table is given the results of various tests under different conditions:

Size and Kind of Drill.	Material.	R. P. M.	Feed Per Rev.	Inches Drilled Per Minute.	Peripheral Speed in Feet Per Minute.	Cu. Ins. Metal Removed Per Minute.
1¼ in. Paragon	C. Iron 3½ in..	500	.050	25	163.6	30.68
1¼ in. Paragon	C. Iron 3½ in..	325	.100	32½	106	39.88
1¼ in. Paragon	C. Iron 3½ in..	475	.100	47½	155	58.29
*1¼ in. Paragon	C. Iron 3½ in..	575	.100	*57½	188	70.56
1½ in. Paragon	C. Iron 3½ in..	300	.030	9	117	15.90
1½ in. Paragon	C. Iron 3½ in..	325	.100	32½	127.6	57.43
1½ in. Paragon	C. Iron 3½ in..	335	.100	33½	131.5	59.19
1½ in. Paragon	C. Iron 3½ in..	355	.100	35½	139.4	62.73
1¾ in. Paragon	C. Iron 3½ in..	235	.100	23½	107.6	56.52
1¾ in. Paragon	C. Iron 3½ in..	350	.100	35	160	84.19
2 5/16 in. Paragon	C. Iron 3½ in..	190	.050	9½	115	39.90
3 in. Paragon	C. Iron 3½ in..	120	.100	12	94	84.82
1¼ in. Paragon	Mch. S. 4¼ in..	350	.030	10½	113.7	12.88
1⅝ in. Paragon	Mch. S. 4¼ in..	225	.040	9	94.8	18.66
2 5/16 in. Paragon	Mch. S. 4¼ in..	165	.020	3¼	100	13.65
2 5/16 in. Paragon	Mch. S. 4¼ in..	200	.020	4	121	16.80
2½ in. Milled	Mch. S. 4¼ in..	150	.015	2¼	98	11.04
2½ in. Milled	Mch. S. 4¼ in..	150	.040	6	98	29.45
2½ in. Milled	Mch. S. 4¼ in..	175	.040	7	114.5	34.36
1¾ in. Paragon	Mch. S. 4¼ in..	275	.030	8¼	125	19.84
3 in. Paragon	Mch. S. 4¼ in..	150	.030	4½	117.8	31.81
3¼ in. Paragon	Mch. S. 4¼ in..	150	.030	4½	127	37.33

It will be seen that a number of these tests are at speeds and feeds which would be economical under average shop conditions, while others are more or less in the nature of "stunts" to show the reserve power of the drills, as well as the great rigidity of the machine and its uniform driving power.

THE CANADIAN PACIFIC RAILWAY is one of the most extensive users of telephone train dispatching on this continent. Its experience is so satisfactory that it has just placed an order with the United States Electric Company of New York and Chicago for 187 additional Gill Selectors on its lines East and 68 additional for its lines West, one selector to a station. Other orders recently for the Gill Selector are 74 stations for the Seaboard Air Line, a pioneer among the Southern roads in telephone train dispatching, and 88 stations for the Atlantic Coast Line.

PROGRESS ON THE EXTENSION TO CONNELLSVILLE, PA.—It has been announced that the last rail on the Western Maryland Railroad extension from Cumberland, Md., to Connellsville, Pa., where it will connect with the Pittsburg and Lake Erie, would be laid not later than August 1. Two months later the company expects to be operating through trains to Pittsburg over the extension and the Pittsburg and Lake Erie roads.

THE PENNSYLVANIA RAILROAD has for some time been conducting a campaign in the interests of good roads. Literature has been disseminated and lectures have been given in a number of towns. The company has announced its desire to do everything in its power to improve the roads radiating from its stations in order that they may be kept open during the winter months, thereby facilitating the movement of freight to and from the stations.

IT IS NOT SAFE TO CONCLUDE that those employers who have had the experience and the profit will be convinced that the most ethically conducted business is the most profitable; that business ideals must be ethical ideals.—*David Van Alstyne before the Congress of Technology, Boston, Mass.*

* This is the highest drilling speed on record.

A STUDY OF THE VENTILATION OF SLEEPING-CARS*

THOMAS R. CROWDER, M.D.

Problems of ventilation confront the designers and operators of all enclosed spaces in which one or more persons are expected to live. Demands for a supply of fresh air must be recognized by those operating hospitals, theaters, offices and to a peculiar degree by those concerned in the management of public conveyances, in which the space for each occupant is necessarily restricted. For the purpose of securing a suitable exchange of air in railway cars many types of ventilators have been suggested and not a few have been given practical tests. About three years ago I was asked to report on the efficacy of one of these which had been applied to a few sleeping cars, which has since been applied to a large number, and which seemed to be of considerable practical usefulness.

In this connection it became evident that it would be necessary to establish some basis of comparison, since it does not seem to have been estimated in exact figures to what degree natural ventilation of a railway car is effective. Inasmuch as the problem is one of lasting importance and is likely to recur, it seemed advisable to make a fundamental study of the question and to place the results within reach of those who might have occasion to make use of them.

A very simple, if somewhat tedious, means of making this investigation was long ago established by Pettenkofer. It consists of estimating the vitiation of the atmosphere by determining the amount of carbon dioxid it contains, and from this computing the amount of air supplied for ventilation.

All air contains carbon dioxid as a normal constituent. The average amount in pure air is commonly stated to be 4 parts in 10,000. This is the figure arrived at by Pettenkofer and the one generally used in ventilation computations, though recent investigation has shown it to be a little too high. Harrington considers the normal as but slightly in excess of three. It varies at different times and places, but the variation is confined within very narrow limits. It is somewhat higher in cities than in the open country. The average for fifteen samples, which were collected in the country districts of Illinois in 1907, was 3.6, with a maximum of 4; for thirty-nine samples from the streets of Chicago during the same period the average was 4.06 with a maximum of 5.

The carbon dioxid in the expired breath averages more than 4 per cent. (400 in 10,000). The amount excreted hourly varies according to age, sex and the degree of bodily activity. In a mixed community of persons at rest it will average about 0.6 cubic feet per person per hour, and the variation will be a small one.

If there were no ventilation whatever the air of an ordinary railway coach, containing 4,000 cubic feet of space and occupied by twenty people, would have 34 parts of carbon dioxid per 10,000 of air at the end of one hour of occupancy; and this would continue to increase indefinitely in a direct ratio to the time, since carbon dioxid continues to be produced by the respiration of the occupants at a practically constant rate. But no car is air-tight, consequently the carbon dioxid will never reach this theoretical limit. Fresh air from the outside is constantly entering through the numerous crevices about the doors and windows, and old air is constantly leaving. The inside air is being constantly diluted.

It is plainly impossible to measure directly the amount of air flowing into a car, since it enters at many points and at constantly changing velocities. But the amount of the interchange may be readily computed from the actual amount of carbon dioxid found from time to time by applying the figures given above to a simple mathematical procedure. To illustrate this problem: Suppose a car contains twenty people and its atmosphere is found to have an average of 10 parts of carbon dioxid per 10,000. The incoming fresh air contains 4 parts of carbon dioxid per 10,000, hence the respiratory contamination of the car air is represented by only 6 parts. Twenty people produce twenty times 0.6 cubic feet, or 12 cubic feet of carbon dioxid per hour. With what amount of air must 12 cubic feet of carbon dioxid be diluted so that the air will contain 6 parts of carbon dioxid in 10,000? The simple proportion, 6 : 10,000 :: 12 : ?, gives 20,000 as the answer. Hence there must be 20,000 cubic feet of air supplied per hour, or 1,000 cubic feet for each person present, in order sufficiently to dilute the carbon dioxid produced so as to maintain its proportion at 10 parts in 10,000. The computation is better represented by the general formula:

$$A = v\,p \div (x - N)$$

where
v = the CO_2 produced by one person (cu. ft. per hour),
p = the number of persons in the room,
x = the proportion of CO_2 found in the air of the room,
N = the proportion of CO_2 in the outside air (0.0004),
and
A = the air-supply to the room (cu. ft. per hour).

By applying the above calculation to the conditions supposed —a room containing twenty people—we find that with the carbon dioxid at 0.0009, or 9 parts per 10,000, 24,000 cubic feet of air, or 1,200 cubic feet per person, would be necessary; at 0.0008, 30,000, or 1,500 cubic feet per person; at 0.0007, 40,000, or 2,000 cubic feet per person, at 0.0006, 60,000, or 3,000 cubic feet per person; at 0.0005, 120,000, or 6,000 cubic feet per person; at 0.00045, 240,000, or 12,000 cubic feet per person; and at 0.0004 an infinite amount per room and per person.

The first attempt to apply Pettenkofer's methods to the air of railway cars and to place our knowledge of their ventilation upon a scientific basis seems to have been made by Wolfhügel and Lang in 1875. Further investigation was carried out under the direction of the Prussian minister of war in 1887-8, in order to determine the best means of ventilating military hospital cars.

Some fifteen or twenty years ago a number of analyses of the air from passenger cars were made by Professor Nickols, working under the auspices of the Board of Railroad Commissioners of the State of Massachusetts. About the same time the Pennsylvania Railroad Company took up the subject and had a few tests made. In 1894 a committee of the Master Car Builders' Association made a somewhat extensive report on the subject of car ventilation, and with it submitted the results of several analyses of the air from sleeping-cars, chair-cars and suburban coaches. Eight observations in sleeping-cars, with an average of 12.5 passengers, gave an average of 18 parts carbon dioxid per 10,000. The highest was 22, the lowest 11.3. Eight observations in chair-cars, with an average of 17.4 passengers, gave average carbon dioxid of 10.7 parts per 10,000; highest 15.5, lowest 7. Six observations in suburban coaches, which are stated to have been one-half to two-thirds full, averaged 13.8 carbon dioxid per 10,000: highest 21.7, lowest 6.9. No record of the conditions under which the samples were taken or of the methods employed are given. It is not stated whether the cars were moving or standing still at the time the observations were made.

In 1904 Dudley reported on a part of some thirty or forty analyses made of the air of cars of the Pennsylvania Company, which were ventilated by the excellent system which he devised. He found from 10 to 18 parts of carbon dioxid per 10,000 in running cars, and 20 to 21 parts in cars standing still for twenty minutes. Fifty-two people occupied the cars, and are assumed to have produced 0.72 cubic feet of carbon dioxid each per hour; from which is estimated 26,000 to 62,000 cubic feet of air-supply per hour for the moving and 22,000 to 23,000 for the still cars.

Numerous reports are to be found upon particular types of ventilators and ventilation systems as applied to railway cars. An excellent and extensive report of this order was made by a committee of the Master Car Builders' Association, in 1908, in which the various systems in general use were reviewed in detail. But unless I have missed important literature on this subject, the information concerning the actual conditions of the air in railway cars is very meager. It is adequate on the application of ventilating devices, but there is no series of analyses extensive enough on which to base any comprehensive opinion as to the deficiencies of natural ventilation to be overcome, or as to the adequacy of the devices applied in keeping the air of the breathing-zone freed from the products of respiration.

The ventilating device* upon which this report is based is designed to remove air by exhaustion from the upper portion of the car, and its operation is dependent on train motion. It was easily determined that it does exhaust air in this way. A long series of anemometer readings, made chiefly by Mr. C. S. Knapp, have shown that each such exhaust ventilator will remove an average of about 15,000 cubic feet of air per hour at a forty-mile train speed, and proportionately more or less for faster or slower speeds. While there is considerable variation under apparently similar conditions, the outward flow is a constant one. One ventilator is placed over each alternate section of a sleeping-car; thus there are six in the sleeping-compartment of the ordinary twelve-section car and eight to a sixteen-section car, while two are applied to the smoking-room and one to a stateroom. Toilet and dressing-rooms are also equipped with one each in recent practice. It is readily seen that a very large volume of air leaves the car each hour through these openings; it must enter somewhere. The question was, does it enter at such places and take such courses as to cause a free dilution of the air at the breathing level in the occupied car? There seems no adequate way to answer this question except by determining the carbon dioxid in such air, from which the amount of dilution may be computed as already indicated. It was desirable also to make determinations in cars not having the exhaust ventilators, but depending upon natural ventilation, for purposes of comparison.

The results of such determinations, while applying particularly to the specific ventilator in use, are to be considered rather as a test of the type—ventilation by exhaustion—as applied to railway cars, and may apply equally to any exhaust ventilator placed in the same location, provided only that the one used

*Presented at the thirty-eighth annual meeting of the American Public Health Association, Milwaukee, September, 1910.

* The ventilator referred to, known as the Garland Ventilator, is furnished by Burton W. Mudge & Co., Chicago.

actually accomplishes its purpose of removing air in large volume and with constancy.

METHODS.

Determinations of carbon dioxid were made by the Petterson-Palmquist apparatus, with a pipette of 20 c.c. capacity. This instrument furnishes a direct volumetric reading of carbon dioxid and should be sensitive to one part in 20,000 of air when carefully used. The accuracy of the method has been amply proven by Teich and others.

About a thousand c.c. of the air to be examined was pumped into a large rubber cautery bulb, arranged with a cut-off, and was then emptied into a two-ounce bottle through a delivery tube leading to the bottom. The bottles were fitted with well-ground glass stoppers, lightly coated with petrolatum, and were immediately sealed after filling with the samples, by pressing the stopper tight and turning it around until no air channels were visible in the petrolatum.

If an average sample of the air was desired, the bulb was filled while walking up and down the middle portion of the car; if of a single place the bulb was filled in place or the air simply pumped through the bottle by means of a small hand bellows. For taking air from an occupied berth a woven tube about 14 inches in length and possessing enough stiffness to stand alone was passed its full length between the curtains into the berth, and air was withdrawn through this into the bottle. The delivery of air was into the bottom of the bottle, the old air being drawn off from the top by suction. Experiment showed that withdrawing through the bottle ten or twelve times the volume of air originally in the container always furnished a fair sample of the air to be tested. The point from which the berth air was taken lies approximately twelve inches behind the middle of the curtain. Comparative determinations from different points in the same berth have shown that this represents a fair sample of the berth air.

The samples of air collected in this manner were opened under a saturated solution of pure sodium chlorid, which had been saturated with carbon dioxid in order to remove any trace of free alkali and exposed to the air. The mouth of the bottle was closed by the finger-tip; it was then removed from the solution and the finger replaced by a rubber stopper, through which a similar solution was immediately let into the bottle from a siphon. This forces the air out through a second very narrow rubber tube about 10 inches in length; and when the whole of the original air contained in this tube is displaced it may be connected to the pipette of the instrument and the air let in for analysis. There is no doubt a trifling interchange of gases between the outside air and that contained in the sampling bottle during the insertion of the rubber stopper; but with the equalized pressure brought about by opening the container under salt solution the change is so slight as to be undetectable and therefore negligible. Saturated salt solution is so slightly absorbent for carbon dioxid that no appreciable error is occasioned by the short time of exposure involved in this procedure.

When the air samples were taken from the cars a record was entered opposite the identifying numbers assigned to them, in which was recorded the date, line, time of day, time of occupancy, name of the car, its distance in car lengths from the locomotive, approximate speed, the place taken, the outside and inside temperature, the direction of the wind, number of passengers, whether doors, windows or decks were open, or whether the exhaust ventilators were used, the kind of lighting; and remarks were added as to the comfort, apparent ventilation, etc. Samples were collected chiefly in the course of ordinary travel, and, in general, no attempt was made to control any of the arrangements, the purpose being to study actual and general conditions as they exist normally.

All of the observations were made during the cooler months of the year, and nearly all when the outside temperature was low. This varied from below zero to 65° F., being in the majority of instances below 40° F.

The larger proportion of observations were made during the night after passengers had retired, and practically every hour of the night is represented by different parts of the work. This was necessary in order to study the chief feature of the sleeping-car, namely, the occupied berth.

Nearly 3,000 carbon dioxid determinations were made for all purposes in connection with this work; about 2,000 of these were of the air from over 200 sleeping-cars. A considerable number were made of the air of day coaches, suburban cars, street-cars, stores, restaurants, offices and the open air for comparative purposes, and others for the purpose of establishing certain facts experimentally.

RESULTS.

Before proceeding to an analysis of the findings it is necessary to know the amount of carbon dioxid in the air surrounding trains in order to have some basis for computing air-supplies to cars. The locomotive emits an enormous total volume of this gas, which, it is easily conceived, might play a considerable part in the amount of carbon dioxid found in the air of the cars. According to Leissner the air surrounding trains contains from 18 to 22.8 parts carbon dioxid per 10,000. My results are at variance with this. Forty-six determinations averaged 4.04; the highest was 10, the lowest 3. A few showing 5 and over were made from the rear platform of trains running in a straight head wind, where the suction effect of the advancing body has a tendency to draw in the overhanging gases. One sample showing 10 and one showing 7.5 were taken in closed vestibules, which generally show no internal contamination. It is a matter of ready observation that any lateral wind carries all the smoke from a locomotive stack well out of the path of the following train. Presumably this is true of the invisible gases as well as the visible carbon. When the wind is straight ahead or directly with the train, the smoke and steam are, as a rule, carried high enough by their propulsion from the stack and their heated condition to allow the train to pass under with a clear interval, the heavier particles only, such as the small cinders, falling in its path. Of course, the smoke and condensed steam do not diffuse as do the invisible gases; but with these is mixed a quantity of sulphur dioxid, for which the sense of smell is very delicate. My observation has been, in the examination of tunnel air, that where flue gases have contaminated the air with 15 to 20 parts of carbon dioxid in 10,000, sulphur dioxid is readily detected. It occasionally happens that sufficient gas is carried into a train running in the open to render sulphur dioxid noticeable. It seems that my determinations of carbon dioxid in the air surrounding trains have not dealt with the conditions that could bring this about. Consequently I conclude that this is a relative rarity, and that 4 in 10,000 is a proper average to deal with in considering the air outside of moving trains. Undoubtedly trains may run for a long distance and be surrounded by only the pure air of the open country, containing not more than 3.5 parts of carbon dioxid per 10,000. It must be realized that conditions may change almost momentarily.

It was not found feasible to make use of all the items recorded at the time of collecting the samples in the analysis of the findings. The distance of a car from the engine appears to bear no definite relation to the amount of carbon dioxid in its atmosphere; the direction and force of the wind is so difficult to follow, especially at night, that it must generally be neglected; a car nearly always contains more carbon dioxid before starting than after it is in motion, so the length of time of its service becomes negligible; the products of illuminating gas combustion are carried out directly through the roof of the car and play no part in the air contamination; a low outside temperature is compensated for by more internal heat and seems to make no constant difference in the air-supply; the actual train speed is of less importance than the relative, that is, the rate and angle at which it cuts the wind.

It was soon observed that a few open windows in a moving train admit such a volume of the surrounding air as to render the respiratory contamination almost undetectable.

So we may dismiss the car with open windows from further consideration, and with it the whole subject of summer ventilation, in so far as the term "ventilation" refers to supplying air and not to keeping the car cool, and turn to the car running in cold weather and with windows closed.

As already intimated, two main types of ventilation will be dealt with: the so-called natural ventilation of cars which are not equipped with any special ventilating devices, and ventilation by exhaustion with the device referred to in a previous section. All examinations were made at the ordinary breathing level unless otherwise stated. The computations of air-supply, or of ventilation efficiency, refer then to the air dilution in this breathing-zone, and to the main compartment of the car.

NATURAL VENTILATION.

The most ordinary condition for the natural ventilation of cars in cool weather is to have the doors and windows closed and a certain proportion of the small windows at the top of the car open. These small windows are herein referred to as "decks" or "deck sash," in order to avoid confusion of the term "window," which will always refer to those along the sides of the car, and of the term "ventilator," which will refer to the exhaust ventilator above mentioned.

From 153 observations made in 44 cars under these conditions the average carbon dioxid was 7.19 per 10,000. The maximum is 13, the minimum 3.5. The average number of passengers for the 153 observations is 15.05. A car carrying this number of people would require 28,300 cubic feet of fresh air hourly to maintain the carbon dioxid at 7.19 parts per 10,000. In other words, there would necessarily be an air supply of 1,880 cubic feet per person hourly.

Adding to the open decks by opening one or both end doors to the vestibule (the outside vestibule doors remaining closed) would be expected to cause a greater air-supply. Such is the case, as was shown by forty-six observations.

The maximum carbon dioxid is 8.5 against 13, while 64.35 per cent. of the determinations are below 6. The average carbon dioxid being 5.40 per 10,000 and the average number of passengers 9.50, there would be required 40,700 cubic feet of air hourly to meet the conditions. It sometimes happens that an

end door is open and practically no air enters through it; on the other hand, an enormous volume may enter; and occasionally air may leave the body of the car through such an open door. These are facts which may be verified by noting the direction and force of the air currents as they pass. Air does not necessarily sweep through cars with doors open to the vestibules, though on the average the air supplied to the breathing-zone in the body of the car is considerably increased. There seems to be no constancy as to which door acts best in the capacity of ventilator. Sometimes the forward and sometimes the rear is most efficient.

Only twelve observations were made where both doors and all of the deck sash were closed. Whatever amount of the outside air enters the car under these conditions must find its way in through natural crevices and is driven in and out by the pressure of the wind and the suction effects produced by the motion of the train

As would be expected under these conditions, the average carbon dioxid is greater than in either of the preceding groups and the computed air-supply is smaller. The maximum carbon dioxid has advanced to 15, while the average is 8.33. Eight and three-tenths per cent. are above 12 and 33.3 per cent. are above 8, while only 16.6 per cent. are below 6. With the average of 8.33 parts of carbon dioxid per 10,000 and 13.33 passengers 18,500 cubic feet of air per hour would be required.

There were only two observations made when all the decks were closed and one end door to the vestibule was open—the rear door in each instance. The number of passengers averaged 9.5 and the carbon dioxid averaged 5.75, which would indicate a ventilation efficiency equivalent to 32,500 cubic feet of air per hour. The number of observations is too small to have any considerable value.

The comparative efficiency of natural ventilation in the four groups of conditions stands: 18,500 cubic feet of air hourly for the fully closed car; 28,300 when from one-fourth to all the decks are open; 32,500 when decks are closed and one door open; and 40,700 where end doors are open in addition to open decks. It is, of course, possible that a larger number of observations would materially change these figures, but it is not probable that their relation to each other would be greatly altered.

VENTILATION BY EXHAUST VENTILATORS.

It has been stated that one ventilator of the type described is fitted above each alternate section of sleeping-cars and that each ventilator will remove an average of 15,000 cubic feet of air per hour at a forty-mile train speed. No special intakes are provided for this air. It goes out; it must come in. But it might come in at such places and take such courses as to play no part in aerating the breathing-zone of the car—might be short-circuited, so to speak. The results of the carbon dioxid determinations of air at the breathing level shows that to a certain extent this must happen, since the air supplied to the breathing-zone, as computed from carbon dioxid determinations, is considerably less than the amount which leaves through the ventilators, as determined by actual measurement. But in spite of this the air-supply is much increased and is better regulated than in cars not so equipped.

Two hundred and ninety-four determinations in 67 cars which were fitted with these ventilators and in which all doors and windows were closed were recorded.

As in the case of natural ventilation, there is here also a considerable variation in the computed air-supplies, though the tendency is to much more pronounced uniformity. The maximum carbon dioxid is 10 parts per 10,000 of air, the minimum 4.5 parts. The average carbon dioxid is 6.20 per 10,000 and the average number of passengers 14.88. There would be required 40,600 cubic feet of air hourly to satisfy these conditions. Of the 294 determinations of carbon dioxid only 4.4 per cent. are over 8 per 10,000 while 46.9 per cent. are below 6 and 95.6 per cent. are as low as 8. Hence the ventilation efficiency is equivalent to at least 1,500 cubic feet per person hourly 95.6 per cent. of the time and is 3,000 cubic feet or more 46.9 per cent. of the time, while it is never less than 1,000 cubic feet.

It will be noticed that the averages of the totals in this table represent essentially the same average ventilation as for those where to a proportion of open decks is added an open door. Probably its proper comparison would be made with the conditions of the first tests noted, when it is seen that there is a distinct advantage in favor of the cars equipped with exhaust ventilators over those ventilated by the decks, and that this advantage represents an average addition in the air-supply to the breathing-level of about 12,000 cubic feet of air per hour.

Forty-eight observations in twelve cars equipped with ventilators and having one or both doors open to the vestibules were recorded.

With an average of 14.48 passengers the carbon dioxid varies from 3.5 to 9, and averages 5.50. It is over 8 but once and is 29 times under 6 (60.4 per cent.). While the totals and average carbon dioxid are very close to those where natural ventilation is carried on through open decks and doors, the number of passengers is greater and the equivalent air-supply is 57,900 cubic feet per hour against 40,700, showing again a distinct advantage in favor of the cars equipped with exhaust ventilators.

For the cars depending upon natural ventilation the general averages of passenger and carbon dioxid for all observations are 13.70 and 6.88, respectively, and the equivalent hourly air-supply 28,500 cubic feet. Averaging all observations in cars when there were—

Less than 10 passengers: 7.48 and 5.91, respectively; equivalent air-supply = 23,500 cu. ft. per hour.

Between 10 and 15 passengers: 13.29 and 6.62, respectively; equivalent air-suppply = 30,500 cu. ft. per hour.

Between 15 and 20 passengers: 17.57 and 7.38, respectively; equivalent air-supply = 31,200 cu. ft. per hour.

More than 20 passengers: 23.18 and 8.85, respectively; equivalent air-supply = 28,700 cu. ft. per hour.

For cars equipped with exhaust ventilators the general averages of passengers and carbon dioxid for all observations are 14.82 and 6.11, respectively, and the equivalent hourly air-supply 42,100 cubic feet. Averaging all observations in these cars when there were—

Less than 10 passengers: 9.10 and 5.58, respectively; equivalent air-supply = 34,600 cu. ft. per hour.

Between 10 and 15 passengers: 13.51 and 5.95, respectively; equivalent air-supply = 41,600 cu. ft. per hour.

Between 15 and 20 passengers: 17.65 and 6.46, respectively; equivalent air-supply = 43,000 cu. ft. per hour.

More than 20 passengers: 23.24 and 7.24 respectively; equivalent air-supply = 43,000 cu. ft. per hour.

THE BERTH.

When taking samples of air from the berths in the manner already described, it was the rule to take, as nearly simultaneously as possible, an average sample from the aisle for comparison. Samples from each place were generally repeated at fifteen-minute intervals, until twenty or more had been collected in the car. Two lower berths on each side of the car were generally selected, availability determining the choice, and one or two uppers when possible.

In testing sleeping-cars not fitted with exhaust ventilators, the average carbon dioxid for all berths is 8.32 and the average ventilation is equivalent to 1,389 cubic feet of air per hour per berth. The lowest average carbon dioxid for the berths of any car is 6.41, the highest is 9.78; inversely, the largest equivalent air-supply is 2,473 cubic feet per hour, and the smallest is 1,038 cubic feet per hour. Of the 321 determinations of carbon dioxid 1.2 per cent. are above 12 per 10,000; 11.2 per cent. are above 10; 44.5 per cent. are above 8; only 2.5 per cent. are below 6, and 55.5 per cent. are 8 or under. Hence, 55.5 per cent. of the determinations indicate that at the moment the samples were taken the air of the berth was diluted with fresh air to an extent that would necessitate ventilation of that berth with 1,500 or more cubic feet of air hourly; it was less than 1,500 feet per hour in 45.5 per cent., less than 1,000 cubic feet in 11.2 per cent., and less than 750 cubic feet in only 1.2 per cent. of the examinations.

If a considerable number of the upper berths are occupied the car is necessarily well filled. The higher number of passengers would logically account for a higher carbon dioxid in the body of the car (average 20.51 passengers and 8.37 carbon dioxid against 16.41 passengers and 7.32 carbon dioxid in the table for lower berths). With open decks it would be expected to find better ventilation in the upper part of the car. On the other hand, when the decks are closed the opposite may be the case.

Of the 41 determinations of carbon dioxid 9.8 per cent. are above 12; 19.5 per cent. above 10; 61 per cent. above 8; 2.4 below 6; and only 39 per cent. are 8 or under. These figures indicate that the ventilation of these berths was equivalent to 1,500 cubic feet or more of air hourly in 39 per cent., less than 1,500 cubic feet hourly in 61 per cent., less than 1,000 cubic feet in 19.5 per cent., and less than 750 cubic feet in 9.8 per cent., while the average ventilation is equivalent to 1,161 cubic feet per berth per hour.

Of 39 times that the comparison can be made the air of the berths contains less carbon dioxid than the aisle at the same time in 17.9 per cent.; it contains more in 61.5 per cent., and they are equal in 20.5 per cent.

Comparison of Lower and Upper Berths in Same Car.—I am able to compare the carbon dioxid, consequently the ventilation, of the lower and the upper berths in five cars.

In two cars there is less carbon dioxid in the air of the lower berths than in the uppers; consequently, the ventilation of these lowers is better than that of the uppers. In the remaining three cars the carbon dioxid is lower in the uppers; consequently, the ventilation of the upper berths is more efficient than for the lower berths in the same cars. There was a total of 91 determinations for the lower berths of these cars, against 34 for the upper berths. The average of these totals gives slightly less carbon dioxid for the lowers than for the uppers; consequently, there was a slightly better average ventilation of the lowers under the conditions represented than of the uppers.

Simultaneous determinations were made for the lower and upper berth of the same section thirty-four times in these cars. The upper had more carbon dioxid than the lower 20 times (58.8 per cent.) less 8 times (23.5 per cent.), and they were

equal 6 times (17.7 per cent.). The relative ventilation is, of course, inversely as the carbon dioxid.

Six hundred and ninety carbon dioxid determinations of the air of lower berths and 53 of the air of upper berths in cars equipped with exhaust ventilators showed that in all but three of the forty-two cars (17, 31 and 37) the average carbon dioxid of the lower berths is higher than the average for the aisle. The average difference for all observations is 0.63 parts per 10,000 of air. The highest for the aisle is 10, the lowest 4.5; for the berths the highest is 13.5 and the lowest 4.5. In 20.4 per cent. of the berths the carbon dioxid is lower than the aisle at the same time; in 63.8 per cent. it is higher than the aisle, and in 15.8 per cent. they are equal.

The average carbon dioxid per berth is 6.96 per 10,000; the average ventilation is equivalent to 2,027 cubic feet per hour. The lowest average carbon dioxid for the berths of any car is 5.38, the highest is 9.34; the largest equivalent air-supply is 4,348 cubic feet per hour, and the smallest 1,123 cubic feet per hour. Of the 690 determinations of carbon dioxid only one, 0.14 per cent. is above 12 parts per 10,000; 3.3 per cent. are above 10; 21.7 per cent. are above 8; 24.5 per cent. are below 6, and 78.3 per cent. are 8 or under. Consequently the ventilation is equivalent to more than 3,000 cubic feet of air per berth hourly in 24.5 per cent. of the berths examined; it is 1,500 or more in 78.3 per cent., and less than 1,500 cubic feet in 21.7 per cent.; it is less than 1,000 cubic feet per hour in 3.3 per cent. and less than 750 cubic feet but once in 690 determinations. In this case 631 cubic feet is indicated.

Of the 53 determinations of carbon dioxid in upper berths the highest is 10.5, the lowest 4.5. There is but one over 10 (2 per cent.); 17 per cent. are over 8; 32 per cent. are below 6, and 83 per cent. are 8 or under. The ventilation is therefore equivalent to more than 3,000 cubic feet per hour in 32 per cent.; it is 1,500 cubic feet or more in 83 per cent.; 1,000 cubic feet or more in 98 per cent., and less than 1,000 in 2 per cent., while the average ventilation is equivalent to 2,222 cubic feet per hour. The berth is higher than the aisle at the same time in 94.3 per cent. and lower in 5.7 per cent.

It seems clear that the average ventilation of the lower berth in this type of car is on the average slightly better than the upper, but the difference is so small as to be of no practical consequence.

In a general way it is found that the average of the berths and of the aisle follow each other consistently. Both vary from time to time in a way that can be only theoretically explained, and an individual berth may show great irregularity.

If we bring into comparison the conditions of the two classes of cars, those without and those with the exhaust ventilators, a decided advantage is seen to lie with the latter in the study of berth conditions, as was before noted in the study of air from the car body. It was possible in only two instances to make direct observations of the comparative ventilation in these two classes of cars under identical conditions by taking samples of the air simultaneously from the two on the same train. The results are shown in Chart I. It will be noticed that the averages lie a considerable distance apart and represent a greater air-supply to the cars with exhaust ventilators in both instances.

THE ENTRANCE AND DISTRIBUTION OF AIR.

It has been shown that an average of over 40,000 cubic feet of air per hour enters the breathing-zone of sleeping-cars equipped with the type of exhaust ventilator herein considered. It has been further shown that approximately twice this much air leaves from the upper portion of the car through the six or eight ventilators used. In the absence of specific intakes it is difficult to determine exactly in what manner this air finds an entrance.

Sleeping-cars are snugly built; the crevices are small; but no crevice is too small to admit air, provided a little pressure is behind it. A row of windows covers each side of the car, another row of small ones extends along each side at the deck level, and each end has a door. There is a sum total of approximately 500 lineal feet of crevices at their edges. If they average one-fiftieth of an inch in width and admitted air at half the rate of the train speed, the 40,000 cubic feet would be more than accounted for. Some of these crevices are much larger than one-fiftieth of an inch, some are probably smaller. It is not unusual to find air entering certain areas of open windows at a rate equal to one-half the train speed, or even more. The crevices may act in the same way; the passage of air through such invisible openings is a much more important means of ventilation than might be thought. Pettenkofer showed that when all visible chinks were closed in a room the rate of ventilation was decreased only 28 per cent. as compared with the rate when the doors were closed in the ordinary way. Putnam showed that air entered a room through a register almost as rapidly when every means was taken to make it air-tight as when the doors stood open. There is no difficulty with the draught of an open fireplace when the room is closed, though each pound of coal consumed causes some 2,600 cubic feet of air to pass up the flue.

Samples of air were taken simultaneously from various locations in sleeping-cars with exhaust ventilators and the carbon dioxid determined, in an attempt to find where the contamination is greatest. So long as the samples are taken well within the body of the car they show nearly uniform results for different levels and different locations; hence the general mixing of the air must be good. The carbon dioxid is, on the average, a little lower close to the floor than higher up. This is consistent with the upward trend of the flow to the ventilator exits. There is essentially no difference between the breathing-zone and the bell-cord level. There is a slight difference between samples taken at the breathing-level and near the ventilator exits, the latter being lower; but the difference is not so great as would be indicated by the difference in the dilution of the lower air and the amount leaving the car through these exits.

The one way in which strikingly different comparative results

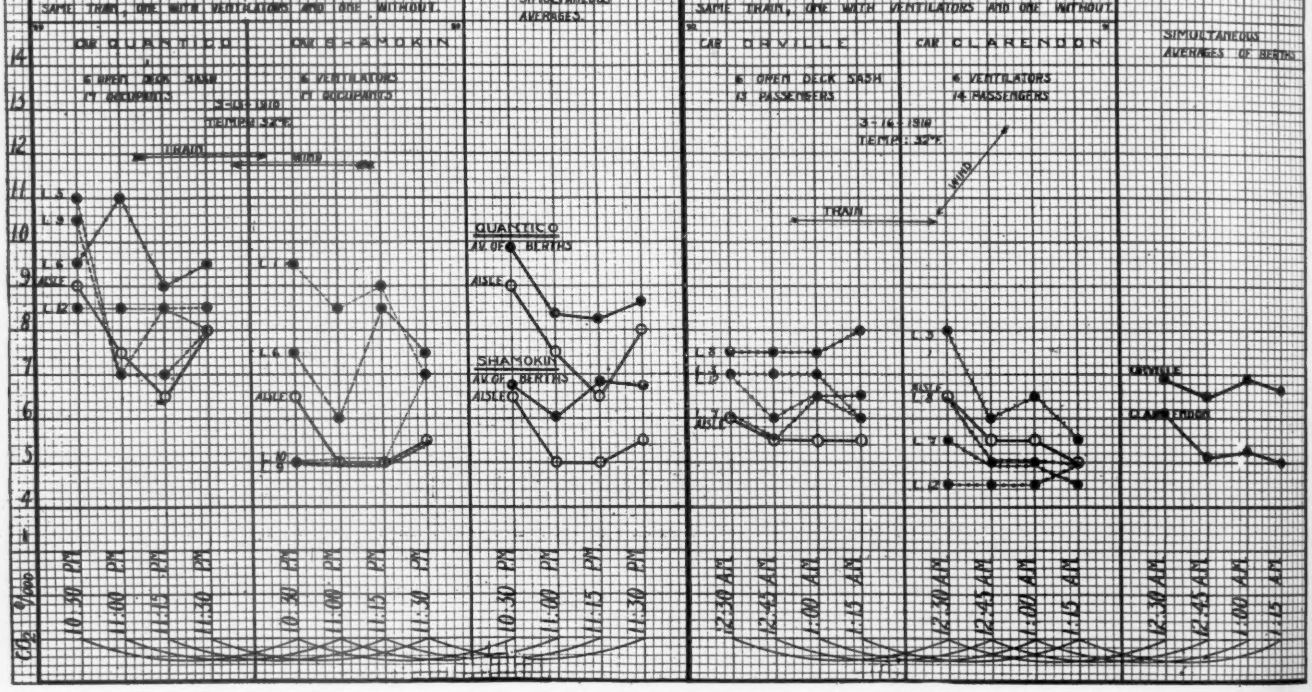


CHART I.

are brought out is by collecting samples from within a few inches of the tops or bottoms of the windows and from the body of the car. Thirty-three such comparisons were made. Twenty-three times the air taken from near the window crevices in this way showed no increase in carbon dioxid over the normal, while the interior had from 5 to 8 parts of carbon dioxid per 10,000. In these twenty-three instances it seems clear that fresh air was entering here at a sufficient rate to drive back all contaminated air for a distance of several inches. It is often possible to feel a draught on the hand placed near to such a crevice, especially if the outside air is cold. Now the least perceptible draught is about two miles per hour. If air is moving at this rate in the several inches lying inside a crevice it must be passing through the crevice itself at a much higher speed. Seven times the carbon dioxid by the windows was 4.5, when the car body showed 5 to 7. Twice it was 5, when the car body was 5.5 and 7. Once it was 6 when the car body was 8. In none of the thirty-three was it equal in contamination to the general air of the car.

Samples were taken from the inner ends of the passageways which lead to the end doors twenty-eight times. Seven times this air showed no contamination; the car body showed 5 to 8 parts carbon dioxid per 10,000. The other samples showed 4.5 to 8. Six times the air from the passage was higher than the average from the car. In one car four successive observations from the rear passageway showed no contamination, while the forward passageway always showed a contamination equal to or greater than the average for the body. It seems clear in this case that there was a continuous flow of air from the rear door inward—and probably an outward flow from the forward end of the car. Both doors were closed.

Even under the older applied principles of ventilation, the air-supply of sleeping-cars, as determined in this study, is ample in summer, or to dry it when excessively humid. Fan motors and open windows are the available means by which the difficulties arising in hot weather may be most readily overcome. Carry away the body heat as rapidly as possible by a strong current of air. Though the avoidance of overheating in winter would seem to be an easy thing, its accurate control to meet the rapidly changing conditions under which cars may be operated is a matter of great difficulty. Experience has shown that it is necessary to have in sleeping-cars at least twice as much radiating surface as is demanded in common practice for heating the same space in houses; this in order to warm the large volume of air received and discharged so that it will maintain comfort to inactive passengers. To decrease this surface would be to fail to maintain a sufficiently high temperature on occasion. A system is needed capable of being quickly and effectively controlled to meet rapidly changing conditions. Such a system is now being experimented with in which there are multiple units of radiating surface, each with a separate control. The results so far indicate that from this a more uniformly comfortable condition can be maintained.

NOVEL NARROW GAUGE LOCOMOTIVE FOR AN INDIAN MOUNTAIN RAILWAY

One of the most interesting locomotives to be constructed in recent years has just been turned out of the shop of Boyer, Peacock and Company, Limited, Manchester, England, for service on the Darjeeling Himalayan Railway of India, where the con-

GARRATT LOCOMOTIVE DESIGNED FOR PARTICULARLY SEVERE CONDITIONS.

under nearly all conditions. The average carbon dioxid in the air of running cars falls well within the limits of contamination permitted by the earlier investigators, and it is relatively rare that the individual observations show more than 10 parts in 10,000. In the light of the newer conceptions, which have as yet been applied in practice only to a very limited extent, this air-supply is ample under all conditions observed. No danger to health is to be apprehended under the conditions ordinarily obtaining even in still cars. They are occupied only for short periods as a rule and are not uncomfortable if kept cool. It would seem that the results obtained by the type of exhaust ventilator investigated in this study, which is now a part of the standard equipment of Pullman cars, are entirely adequate to meet the demands of hygiene, and that those difficulties and discomforts which do sometimes arise are due to other causes than lack of a sufficient amount of fresh air or to excessive vitiation. It is extremely unlikely that increasing the air-supply, which now amounts to from six to ten or more times the cubic content of the car each hour, and must maintain considerable motion of the atmosphere, would aid in any other way than by making overheating more difficult to bring about. Overheating is the paramount evil. It is the thing to be chiefly guarded against in the attempt to maintain comfort and good hygiene. It is not feasible to cool the naturally overheated air

ditions call forth requirements of a particularly exacting character, in fact without a parallel in the instance of smooth rail operation.

This is a narrow gauge line, 51 miles long, which was begun in 1879 and completed in 1881. Starting from Siliguri, 398 feet above the mean sea level, the line rises to a height of 7,407 feet at Ghoom Station, 47 miles away, and then descends to Darjeeling, four miles further, the terminus itself being 6,812 feet above sea level. The construction of this line, although only two feet gauge, presented, as may be imagined, serious difficulties, the steep ascent necessitating frequent loops or spirals and reverses, one of these latter having gradients of 1 in. 28 ft. The average ascent for the forty miles between Sookna and Ghoom is 170 feet per mile. For the first seven miles to Sookna Station the gradient is a gentle one, but from this point to the summit at Ghoom the average grades in the sections vary from 1 in 29 to 1 in 37, and there are many cases of curves of 70 ft. radius.

It was specified that the "Garratt" locomotive so-called, should

be able to negotiate reverse curves of 60 feet radius with a length to tangent between the curves of 20 feet only. Of this 20 feet tangent only 6 feet are level, as at 7 feet from each end the angle begins which raises the tangent to the super-elevation of 2½ inches on the outer rail of the curves. A trial line fulfilling these conditions was laid down in the ample extension grounds of the builder's works. The illustration of this new duplex locomotive, which briefly described may be said to consist of three main parts, viz., the boiler and frame and two motor bogies shows clearly the characteristic disposition of the component parts of the locomotive.

The general arrangement is that of the duplex truck, but beyond this it has little in common with other known types. Instead of the boiler being placed above the wheels as has hitherto been the practice, it is carried upon a girder frame which is pivoted and supported at its extreme ends on trucks, each of which may be likened to a locomotive without a boiler. These steam trucks with their water tanks and coal bunker together constitute the greater part of the weight of the locomotive and give stability to the running; furthermore, the center line of the boiler portion connecting the two trucks forms a chord of the curve on which the engine may be travelling, and the sharper the curve the greater will be the projection of the boiler weight towards the center of the curve.

Comparing the "Garratt" type with other forms of articulated locomotives, it will be seen that the most vital and novel element is contained in the fact that the boiler lies completely between the two main connecting points of the boiler frame, without the boiler frame materially overhanging the connecting points. In all other articulated types the frame is superimposed upon the trucks and extends over the whole or nearly the whole length of the machine. The first consequence of the Garratt form of construction is that the size of the boiler and size of wheels and tank accommodation need never be considered in relation to one another, merely by reason of the limitations hitherto imposed, for as there are no wheels under the boiler in this type of locomotive, and no side tanks on the carrying frames, the boiler is unrestricted as regards the position of its center line or as regards its diameter. It is therefore possible with this type to get the maximum boiler requirements with a relatively short boiler. The size of the boiler does not affect the size of the wheels, as the boiler is suspended between the trucks carrying the wheels and bunkers.

A second consequence of the arrangement is that there is no part of the boiler-carrying frame materially overhanging the truck centers, and that both of the trucks are constructed as tank trucks carrying fuel and water supply tanks as integral portions of themselves. It will be seen, therefore, that a type of locomotive is hereby created possessing perfect pliability and stability combined with entire freedom from the usual restrictions which have hitherto governed the construction of the articulated locomotive. The trucks are designed so that the weight is well distributed and alterations of the amount of fuel and water carried affect the distribution to only a slight extent. The weight of fuel and water bears but a small proportion to the weight of the trucks and to the load they have to bear, and the chief point to be cared for is the correct placing of the truck center with regard to the center of gravity of the truck. In the case of the engine illustrated the figures given for the weight on the truck will show how well the total engine weight is distributed.

Turning to some details of the locomotive illustrated, which is the first to be built for this particular railway, it will be observed that in the arrangement embodied the whole of the adhesion weight is carried by the coupled wheels. The cylinders are four in number and are 11 inches in diameter by 14 inches stroke. They are placed outside the frames with their slide valves above, and are worked by the Walschaert valve gear. The frames are placed outside the wheels, and the journal boxes and springs outside the frames. Outside cranks are provided with counterbalance extensions. The water tanks, which have a total capacity of 850 gallons, are three in number, one being placed on the truck at the smokebox end, one underneath the boiler barrel, and the third combined with the fuel bunker is fixed on the truck at the firebox end. All these tanks are connected by means of suitable piping, and are filled through the fillholes seen in the photograph at either end of the engine.

An interesting feature is the design of the truck centers. There is a flat surface at the firebox and as well two side bearing surfaces. At the smokebox end the swivelling surface is dished, and there are no side bearing surfaces. The effect is, therefore, to give to the boiler-carrying frame a three point suspension, which gives the whole machine a remarkable capacity for adjusting itself to the several curves and super-elevation of the rails.

The boiler barrel is 3 ft. 10⅞ in. outside, and 7 ft. long, and the firebox shell, which is of the Belpaire form, is 4 ft. 8 ins. long and 4 ft. 9½ ins. wide, with internal firebox of copper. It will be observed that the provision of a boiler of large capacity with wide and deep firebox has presented no difficulty even with so small a gauge as 2 ft. The boiler is placed in a plate framing, and is fixed at the smokebox end; allowance for expansion is, as usual, provided at the firebox end. Drummond duplex safety valves loaded to 160 lbs. pressure are carried on the dome, and two of Gresham & Craven's No. 8 injectors are provided. The frame is built up of plates, angles, etc., the main longitudinals being ¾ inches in thickness. The throttle valves are provided in the dome, with independent rods and levers arranged to work together or disconnect one from the other. One goes to the smokebox in the ordinary way, and one to the rear is brought out through the back of the firebox and underneath the footplate to the truck center. Connection with the steam pipes to the cylinders is made through ball joints on the center line of the truck pivot into a pair leading to the exhaust pipe in the stack, to which the exhaust from the front truck cylinders is also connected by means of a sliding pipe with universal joint. This is plainly seen in the sectional view. The axles and tires were supplied by Messrs. Vickers, Son & Maxim, Ltd. The couplings are of the standard Darjeeling Himalayan type, and fenders are provided as rail guards. Both trucks are provided with the vacuum brakes, and there is also a hand screw brake to the rear truck. The principal dimensions are as follows:

Cylinders, outside	4
Cylinders, diameter and stroke	11 in. by 14 in.
Boiler length	7 ft.
Boiler diameter outside (at front)	46⅞ in.
Tubes, No. and diameter	195—1⅝ in.
Heating surface, tubes	603 sq. ft.
Heating surface, firebox	64 sq. ft.
Heating surface, total	667 sq. ft.
Grate area	17.5 sq. ft.
Boiler pressure	160 lbs.
Tractive force per lb. of mean effective pressure in cylinder	130.2
Wheelbase—centre to centre of trucks	17 ft. 3 in.
Truck wheelbase	4 ft. 3 in.
Total wheelbase	24 ft. 6 in.
Weight on front truck	30,820 lbs.
Weight on rear truck	31,660 lbs.
Weight, total	62,480 lbs.
Tank—Water capacity	850 gallons
Fuel space	1 ton of coal

ENORMOUS GROWTH OF RAILROAD EARNINGS.—On July 1, 1901, there were in the United States reporting to the commission, 195,561 miles of railway, yielding a gross operating revenue of \$1,572,960,868, or \$8,043 per mile. The net operating revenue amounted to \$577,221,171, or \$2,951 per mile. On July 1, 1910, there were 238,411 miles of line, with \$2,818,411,419 gross income, or \$11,822 per mile. The net operating revenue reached the unparalleled figure of \$932,848,978, or 3,913 per operated mile, an increase of 50 per cent. in net per mile over the figures of ten years ago.

STEEL PRODUCTION IN 1910.—The production of all kinds of steel ingots and castings in the United States in 1910, according to the American Iron and Steel Association, amounted to 26,094,919 tons, against 23,955,021 tons in 1909, an increase of 2,139,898 tons, or almost 9 per cent. The output in 1910 was the largest in the country's history. The year of the next largest outturn was 1909.

ALUMINUM PULLEYS ON PLANERS

Anyone acquainted with planers is familiar with the fly-wheel action of the tight pulley. Especially on a planer with a high countershaft speed, this is a very serious and costly feature, and much valuable time is lost by the over run of the table at each end of the stroke, to overcome which the belts must be tightened up to such an extent that they very soon wear out the loose pulleys. Another serious feature is the rapid deterioration of the belts. The friction and its resultant heat, caused by the belt overcoming the momentum of the tight pulleys at the instant of reverse, causes rapid wearing of the belts and very soon destroys them.

Experience has shown that the substitution of an aluminum pulley for the cast iron in the case of a 36-in. planer where the two pulleys weigh 35 and 105 lbs. respectively, completely overcomes these conditions. By applying the formula for momentum it is found that the aluminum alloy pulley of the same dimensions, and running at the same velocity as the cast iron pulley, will, by virtue of its lower specific gravity, develop less momentum, in the same proportion as the difference between the specific gravities of the two metals. Therefore, the aluminum under the same running conditions will develop only about one-third of the momentum that a cast iron pulley will. The advantages of this are readily apparent. The belts do not have such a tremendous force to overcome, and will, therefore, "pick up" more quickly, thus effectually eliminating practically all over-run of the table.

At first thought it may seem that the over-run of the table is more largely due to the momentum of the table itself than to that of the driving pulley; however, the contrary is the truth. By using the formula for calculating the momentum of the table and of the cast iron driving pulley on an "American" 36 in. x 10 ft. planer, it will be found that the momentum of the pulley is over 56 times that of the table. In other words, if the momentum of the table were sufficient to cause an over-run of one inch, the momentum of the driving pulley would cause an over-run of approximately 56 inches. Calculating the momentum of the table and aluminum pulley by the same formula as used above, it will be found that the momentum of the pulley is only 15 times that of the table.

Recognizing the importance of these features, the American Tool Works Company of Cincinnati carried out a long series of practical tests in its own shop which fully proved the practical advantage to be derived and this company now announces that all of its larger-sized planers, 36-in. heavy pattern and up, will be fitted with aluminum alloy pulleys. This new pulley is very similar in construction to the regular cast iron pulley formerly furnished, the only decided difference being the design of the arms, which are made "S" shape, thus permitting sufficient elasticity to prevent any possible breakage, due to the arms shrinking away from the rim.

M. M. & M. C. B. COMMITTEES

It has been announced by the secretary that the selection of committees for the ensuing year is as follows:

M. M. STANDING COMMITTEES.

Advisory Technical: G. W. Wildin, A. W. Gibbs, W. A. Nettleton.

Revision of Standards: T. W. Demarest, J. D. Harris, W. E. Dunham.

Mechanical Stokers: T. Rumney, E. D. Nelson, C. E. Gossett, J. A. Carney, T. O. Sechrist, S. K. Dickerson, George Hodgins.

M. M. SPECIAL COMMITTEES.

Specifications for Cast-steel Locomotive Frames: E. D. Bronner, E. W. Pratt, R. K. Reading, O. C. Cromwell, C. B. Young, C. E. Fuller, L. R. Pomeroy.

Main and Side Rods: W. F. Kiesel, H. Bartlett, G. Lanza, H. P. Hunt, W. E. Dunham.

Consolidation: D. F. Crawford, H. H. Vaughan, G. W. Wildin.

Safety Valves: F. M. Gilbert, James Milliken, W. D. Robb, Prof. E. C. Schmidt, W. J. Tollerton.

Safety Appliances: H. T. Bentley, M. K. Barnum, C. B. Young.

Design, Construction and Maintenance of Locomotive Boilers: D. R. MacBain, C. E. Chambers, T. W. Demarest, F. H. Clark, R. E. Smith, E. W. Pratt, J. Snowden Bell.

Contour of Tires: W. C. A. Henry, J. A. Pilcher, O. C. Cromwell, H. C. Oviatt, O. M. Foster, G. W. Seidel.

Steel Tires: L. R. Johnson, J. R. Onderdonk, C. H. Hogan, R. L. Ettenger, L. H. Turner.

Flange Lubrication: M. H. Haig, T. W. Heintzleman, D. J. Redding, A. Kearney, W. C. Hayes.

Minimum Requirements for Headlights: D. F. Crawford, A. R. Ayers, C. H. Rae, F. H. Scheffer, J. W. Small, F. A. Torrey.

Standardization of Tinware: A. J. Poole, M. D. Franey, J. C. Mengel.

Maintenance of Superheater Locomotives: R. D. Smith, W. H. Bradley, H. H. Vaughan, Jas. Chidley, J. B. Kilpatrick.

Arrangements: H. T. Bentley.

M. C. B. STANDING COMMITTEES.

Arbitration: J. J. Hennessey, T. W. Demarest, J. S. Lentz, W. A. Nettleton, E. D. Bronner.

Revision of Standards and Recommended Practice: R. L. Kleine, W. E. Dunham, T. H. Goodnow, W. H. V. Rosing, C. E. Fuller, T. M. Ramsdell, O. C. Cromwell.

Train Brake and Signal Equipment: R. B. Kendig, T. L. Burton, B. P. Flory, E. W. Pratt, B. K. Reading.

Brake Shoe Equipment: Prof. C. H. Benjamin, C. D. Young, R. B. Kendig.

Coupler and Draft Equipment: R. N. Durborow, G. W. Wildin, F. W. Brazier, J. F. DeVoy, F. H. Stark, H. La Rue, H. L. Trimyer.

Rules for Loading Materials: A. Kearney, R. E. Smith, C. H. Osborn, L. H. Turner, W. F. Kiesel, Jr.

Car Wheels: William Garstang, W. C. A. Henry, A. E. Manchester, R. W. Burnett, R. L. Ettenger, J. A. Pilcher, O. C. Cromwell.

Safety Appliances: A. Stewart, A. La Mar, C. B. Young, H. Bartlett, T. M. Ramsdell, M. K. Barnum, W. O. Thompson.

M. C. B. SPECIAL COMMITTEES.

Car Trucks: A. S. Vogt, C. A. Seley, J. J. Tatum, F. P. Pfahler, R. W. Burnett, N. L. Friese, G. A. Hancock.

Prices for Labor and Material: F. H. Clark, G. E. Carson, C. F. Thiele, Ira Everett, B. Julien, S. T. Park, H. E. Passmore.

Springs for Freight Car Trucks: F. M. Gilbert, W. F. Kiesel, Jr., W. E. Sharp, T. A. Lawes, J. R. Onderdonk.

Consolidation: F. H. Clark, W. A. Nettleton, C. A. Schroyer.

Train Lighting and Equipment: T. R. Cook, C. A. Brandt, Ward Barnum, J. H. Davis, E. A. Benson, D. J. Cartwright, E. W. Jansen.

Train Pipe and Connections for Steam Heat: I. S. Downing, C. A. Schroyer, W. C. Arp, T. H. Russum, J. J. Ewing.

Nominations: J. F. Deems, A. W. Gibbs, C. A. Seley, W. H. Lewis, J. F. Walsh.

Arrangements: A. Stewart.

Tank Cars: A. W. Gibbs, C. M. Bloxham, J. W. Fogg, S. K. Dickerson, C. E. Chambers, E. J. Searles, T. Rumney.

Specifications for Tests of Steel Truck Sides and Bolsters for Cars of 80,000, 100,000, 150,000 *Pounds Capacity:* Prof. E. C. Schmidt, J. S. Sheafe, C. D. Young.

Capacity Marking of Cars: C. E. Fuller, J. F. Deems, M. K. Barnum, A. W. Gibbs, F. H. Clark.

Revision of Constitution: D. F. Crawford, C. A. Seley, A. Kearney.

Lettering Cars: D. F. Crawford, J. F. Deems, F. H. Clark, W. A. Nettleton, F. A. Torrey.

Individual Paper, Car Shop Apprentices: I. S. Downing.

POWERFUL CYLINDER BORING MACHINE

In the accompanying illustration is shown a newly designed cylinder boring machine which has a capacity for boring up to 40 inches in diameter and boring and facing cylinders up to 50 inches in length. This machine is very powerful and is constructed in every particular to maintain its rigidity and accuracy under the most severe working conditions. A consideration of some of the details of construction clearly indicates this feature as well as the efficiency and convenience of operation.

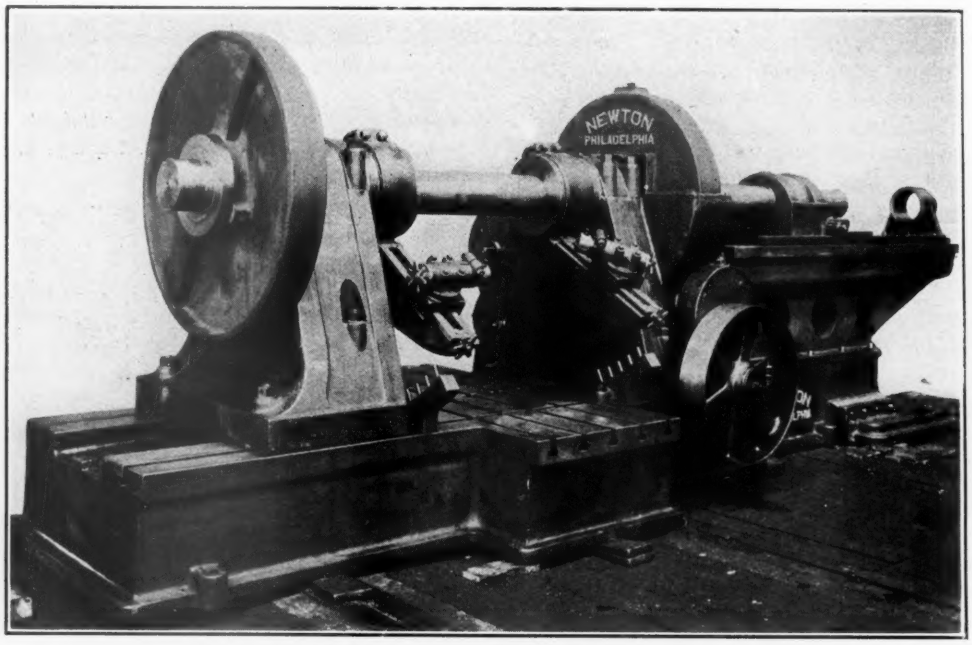
The spindle is 8 in. in diameter and is driven by a sleeve which revolves in a bearing at each end of the head, having a length over all of 33 in. On the center of the spindle sleeve between the two end bearings, is mounted the driving worm wheel, which has a cast iron center in a bronze ring, into which are cut 6-in. pitch triple lead teeth; the driving worm is of hardened steel with roller thrust bearings. The outer end of the spindle is arranged to drive a spindle sleeve having a bearing of large diameter, about 20 in. in length in the outboard head. The feed motion to the bar is transmitted by means of a trolley yoke with which any number of grips on the bar may be taken, motion being transmitted to the trolley by means of two pinions meshing in racks on each bearing of the horn, as shown in the illustration. The facing arms are mounted on extensions of the spindle sleeves, permitting the adjustment of the spindle without removing the facing arms.

As shown, this machine is furnished when desired, with a counterbalance to equalize the weight of the facing arms and insure a steady even motion of the spindle when boring and facing at the same time. Where desired, the facing arm can remain stationary while the spindle rotates; the facing arms are furnished with swiveling tool holders, mounted on a slide having reversing power feed.

The particular machine illustrated is intended to be variable speed motor driven from the single pulley shown, on which is mounted spur gears transmitting the motion to the driving worm. The motion for the feed is taken from the end of the driving worm shaft to an idle male friction gear for the fast traverse, and to a worm wheel for the feed; the worm wheel is mounted on the feed box shaft which through the different combinations gives nine changes of gear feed. A hand lever operates the friction clutch controlling the fast traverse of the spindle, also the tooth clutch engaging the feed. With this design of drive and feed, it is possible to obtain a great variation in the spindle speed, although the present machine is arranged for three to nine r. p. m. of the spindle, and feeds from .062 in. to .647 in. per revolution of the spindle.

The length of the feed is 72 in., distance from center of spindle to top of work table is 37½ in., the working surface being 34 in. wide by 71 in. long.

This machine is built by the Newton Machine Tool Works, Philadelphia, Pa.



NEWTON CYLINDER BORING MACHINE.

ASSIST THE MANUFACTURERS

To encourage the maintenance of standards, and uniformity of design, it is sometimes good business policy to purchase finished products from the manufacturer at a cost slightly higher than some of the detail parts could be manufactured by the railway.

I have in mind at this time the air brake equipment, with its various designs, its multiplicity of parts, each design classified, each part symbolized.

The organization of this industry is so perfect as to standardize the air brake equipment on the railways of the world, any part great or small is symbolized in its class, and will interchange with any of the hundreds of parts for which it is symbolized, wherever they may be found.

Improved designs have been developed as required to meet new conditions, an efficient corps of experts are employed to design, build and improve these features, they check the service, note defects and assist in developing perfection.

This organization increases the overhead charges, though it insures a more perfect air brake equipment; its cost of maintenance must be spread over the product of the plant and be paid for by the consumer.

The above applies to many other manufacturers who devote their time and energy to the design and development of railway specialties. I am mindful of the assistance rendered by the railway organization in suggesting and assisting to perfect these designs when I say such industries should be encouraged as far as consistent with sound business methods.—*M. D. Franey at the Railway Storekeepers' Convention.*

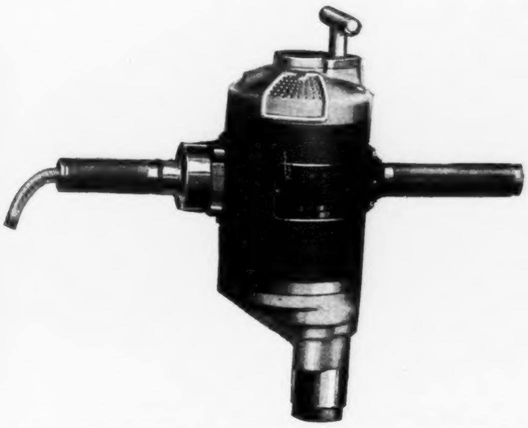
THE PRESENCE OF BISMUTH IN BRASS is one of the causes of its fire cracking when annealed, but more is required to produce the cracking than is ever found in the copper from which commercial brass is made. While a possible cause of fire cracking, it is one of the least frequent.

PORTABLE ELECTRIC DRILLS & REAMERS

In many railroad shops power for portable drills and reamers is cheaper in the shape of electric current than it is with compressed air, and when the greater convenience, less weight and general advantage of a smaller motor found in the latest electric portable machines is considered it is not surprising that so much interest was aroused at the last Atlantic City convention by the exhibit of the Van Dorn and Dutton Co. of Cleveland, Ohio.

This company had on exhibition and in operation eight different types of machines, six for direct current and two for alternating current ranging in capacity for drilling in steel from ⅛ to 2 inches diameter. While the portable electric machines are a comparatively new thing, this demonstration showed that most satisfactory progress has been made in their development and that all reasonable requirements can now be fulfilled.

In the construction of the Van Dorn & Dutton machines straight series motors, developing the greatest factor of power obtainable for size and weight, are being used. The armature is of the slotted drum type, built up of soft, steel laminations,



PORTABLE ELECTRICAL DRILL OF EXCEPTIONAL POWER.

on a hollow shaft, these laminations being made from steel of a special analysis to give the highest efficiency. Each lamination is carefully and uniformly insulated. In the larger machines the field frames are constructed of steel of a special analysis, by means of which the best results are obtained. In the smaller machines, the field frames are built up of laminations much in a manner similar to the armature.

Exhaustive consideration has been given to the matter of lubrication and bearings, experience having proven that these two features are of the greatest importance in the construction of tools of this character. The gears are enclosed in a gear case, entirely separate from the windings, this gear case serving as a lubricant chamber, as well as a housing for the gears. By means of canals lubricant reaches all bearings, with the exception of that supporting the spindle, which is lubricated by a receptacle easily accessible. In revolving, the gears force the lubricant through these canals, insuring a proper and sufficient supply at all times. The oiling system is so devised that one charge of non-fluid oil in the gear case will answer for several weeks. Ordinary machine oil can be used for lubricating the spindle.

The wipe system employed at the spindle is so arranged that the wick is constantly in contact with the spindle, extending into the oil chamber. The bearings are proportioned with an excess factor of safety. The system used was adopted after exhaustive consideration of the subject on the part of experts in this branch of engineering and has withstood the severest tests.

In the larger machines for reaming, mechanically operated automatic switches are used, which will automatically stop the machine should the operator accidentally release the handles when the tool is in operation. These switches will at all times break the current instantaneously, thus eliminating a heavy and destructive arcing. In the smaller machines switches of a special design are also employed, the design used being strong mechanically. The switch contacts are so designed that when wear is shown, they are easily replaced at a very small cost.

The general construction of this line of machines is such that the tools are easily assembled and disassembled, all parts being interchangeable and easily accessible.

In the larger machines four-pole construction is employed, whereas the small tools are of the two-pole construction. The design is such that the harder the tool is forced, the greater the torque or working power.

COLUMBIA HIGH SPEED UNIVERSAL CHUCK

If the full advantage of high speed tool steels are to be obtained it is as necessary that the chuck used should be adapted and suited to its work as it is that the machine tool should be more powerful and rigid. Recognizing that the ordinary

NEW TYPE OF CHUCK.

chuck was proving the weak link in the chain, Schuchardt and Schutte, 90 West street, New York, have put on the market a new type of chuck which is designed throughout for use with the heaviest cuts and to maintain its accuracy and grip indefinitely under the most severe service.

This chuck is constructed along entirely new lines, as is shown in the illustration. The spiral thread for moving the jaws in and out is "V"-shaped and is cut on the sloping inside surface of a steel ring, which is hardened and subsequently ground to obtain the greatest accuracy in regard to true running. The pitch of the thread, as is shown in the drawing, is considerably finer than that of the ordinary scroll chuck, thereby increasing

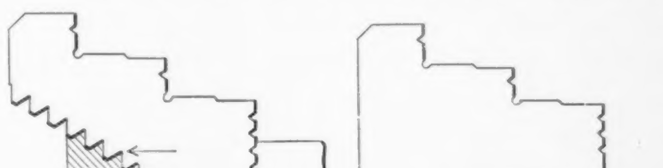


ILLUSTRATION OF ADVANTAGE OF THE "V" THREAD.

the gripping power and area of wearing surface. This chuck, however, is not adapted for holding rings, etc., on the inside. The sloping surface of the body gives greater support to the jaws and insures the greatest possible rigidity. The jaws are almost covered by the chuck body and do not protrude, reducing the possibility of accidents to the operator, by being caught by the hands or clothing. Owing to the ground surface on the spiral steel ring, the friction on the ways is reduced to a minimum.

Iron Pipes Lined with Lead are made for the transmission of acids which would quickly destroy unprotected iron. These pipes are made up to large sizes. One copper smelting company, for instance, has 30,000 ft. of 10 in. pipe lined with lead which has been in use twelve years.

AUTOMATIC WATER WEIGHER

In many cases it is of great advantage to have an accurate knowledge of the amount of water being used in boilers, for cooling, for washout systems, etc., especially where it can be determined for any desired interval of time with reliable accuracy. Such knowledge has often resulted in the discovery of unthought-of sources of waste and permits the constant maintenance of a high state of efficiency in certain features with its reflected effect on many others.

An apparatus remarkable for its simplicity, which is guaranteed to record the correct weight of the water used within one-half of one per cent., has recently been perfected by The Kennicott Co., Chicago Heights, Ill., and is shown in the accompanying illustration.

It consists of a shell, the lower part of which is divided by a partition into two measuring or weighing compartments, a siphon being provided in each compartment for discharging the water when the full unit charge has been received. A tipping box composed of two halves, which alternately fill with water, serves the double purpose of furnishing a sufficient quantity of water to start the siphons and to shift the supply from one compartment to the other. This tipping box is balanced on pivots, being mounted directly above the weighing compartment and is operated by floats, one in either compartment.

The operation of the weigher is as follows: Water enters the inlet and passes to the tipping box, where a small portion of it is intercepted, the remainder passing directly to the weighing compartment below. When this compartment is nearly filled, the float tips the tipping box, thereby automatically spilling the water contained in the tipping box into the compartment, thus completing the unit charge and starting the siphon which discharges the unit charge, while the entering water passes to the opposite half of the tipping box and into the opposite compartment, which fills and empties in a like manner. A counter registers each double unit charge delivered by the weigher, and is so arranged that it cannot be tampered with by unauthorized persons.

The complete equipment with the Kennicott Water Weigher includes a storage tank and balanced pressure inlet valve. The balanced pressure inlet valve is controlled by a ball float in the storage tank below the weigher, which automatically regulates the supply to meet the varying demands of the plant and insures that the storage tank is always full of water.

Especial attention is given to the careful test and calibration which each weigher receives before being shipped. The unit charges are accurately weighed on scales and a certificate of accuracy and capacity accompanies each shipment. The weigher is guaranteed to record the correct weight of water to within one-half of one per cent. of absolute accuracy and repeated tests, made by checking the weights on scales, while weighers are under actual operation, show that the results obtained by its use are much more accurate than those obtained by hand weighing, especially when the liability of errors in reading the scales and recording the weights in the latter method is taken into account.

KENNICOTT WATER WEIGHER.

THE COLLEGE OF ENGINEERING of the University of Illinois, at the commencement exercises on June 14, 1911, conferred the bachelor's degree in engineering upon 202 men, the master's degree upon nine men and the professional degrees of civil engineer, mechanical engineer and electrical engineer upon eight, four and five men, respectively. The honorary degree of doctor of engineering was conferred upon Mr. Ralph Modjeski, bridge engineer.

THE RESULTS OF THE INVESTIGATIONS into the briquetting of lignite have just been published by the Bureau of Mines in Bulletin No. 14. Charles L. Wright, who conducted the tests and who is author of the bulletin, declares that enough testing has been done to indicate that some American lignites equal German lignites in fuel value and can probably be made into briquets on a commercial scale without the use of binding materials. This bulletin can be obtained by writing to the Director of the Bureau of Mines, Washington, D. C.

POSITION WANTED

Car Draftsman.—Car company preferred. Four years' experience with all classes of steel and wooden equipment. Address G. H. A., care American Engineer.

Mechanical Engineer or Supervisor of Apprentices.—Technical graduate with very full experience covering 16 years in shops, drawing rooms and apprentice work. Address J. S., care American Engineer.

Young Man with a practical education, and five years' experience on premium and bonus systems, desires connection with a substantial company wanting a higher shop efficiency. Best references. Address F. H. M., care American Engineer.

Mechanical Man scientifically trained, eleven years' shop and drawing room experience, and in locomotive and railway supply line. At present is assistant chief draftsman of a large manufacturing concern, but desires position as chief draftsman or designer. Address M. S. W., care American Engineer.

BOOKS

Poor's Manual of Railroads for 1911. 44th Annual Number. Cloth. 5¾ x 8½ in. 2,690 pages. Published by Poor's Railroad Manual Co., 68 William street, New York. Price $10 delivered.

In this, the 44th annual number of Poor's Manual, the innovations instituted in the 1910 edition have been continued and analytical tables permitting a comparison of the financial strength as well as the operating efficiency of the different roads are given. All information given in the manual is official.

The Spontaneous Combustion of Coal with Special Reference to Bituminous Coals of the Illinois Type, by S. W. Parr and F. W. Kressmann. Bulletin No. 46 of the Engineering Experiment Station of the University of Illinois. Copies free on application to W. F. M. Goss, Urbana, Illinois.

The Bulletin describes a series of experiments directed toward the determination of the fundamental causes underlying the spontaneous combustion of coal. These causes may be summarized as follows: (1) External sources of heat, such as contact with steam pipes, hot walls, and the impact of large masses in the process of unloading, height of piles, etc.; (2) fineness of division; (3) moisture; (4) activity of oxidizable compounds, such as iron pyrites. An historical review of the literature upon the spontaneous combustion of coal is given in the Appendix.

Proceedings of the International Railway Fuel Association. Published by the Association. D. B. Sebastian, Sec., La Salle Street Station, Chicago. Price $2.00.

At the third annual convention of this association held at Chattanooga, Tenn., papers on the following subjects were presented and discussed: Fuel investigation under the Bureau of Mines, by J. A. Holmes; How to organize a railway fuel department and its relation to other departments, by T. Duff Smith; Some results of purchasing coal on a mine-run basis, Prof. A. A. Steel; Testing of locomotive fuel, by F. O. Bunnell; The railway fuel problem in relation to railway operation, by R. Emerson; Petroleum—its origin, production and use as a locomotive fuel, by Eugene McAuliffe. The copy of the proceedings contains the full text of the papers and the discussion as well as a list of members, copy of constitution, etc.

Railway Shop Kinks. Compiled by Roy V. Wright under the direction of a committee of the International Railway General Foremen's Association. Cloth. 8½ x 11½. 290 pages. Illustrated. Published by the *Railway Age Gazette*, 83 Fulton street, New York. Price, $2.00.

During the past two years the *Railway Age Gazette* has conducted a series of prize competitions for the best collection of home-made and original shop devices, and published the contributions submitted in a special shop section constituting a part of the first issue of each month. These competitions brought out a very large number of devices of this kind used in railroad shops. These articles have now been collected, assorted and systematically arranged by R. V. Wright, Mechanical Dept. Editor, and are being issued in book form. The arrangement adopted groups all devices used in each particular department together and presents them in alphabetical order. This, when taken in conjunction with the very complete index provided, permits a quick and ready reference to any desired device.

Handy devices or kinks of this kind are of inestimable value to any railroad shop, and to have a collection as large as this available for ready reference will be greatly appreciated by all foremen and master mechanics. The articles have all been carefully revised by the compiler and each is fully illustrated, permitting the device to be easily duplicated by anyone. Full credit is given as far as possible to the original designer and to the contributor. No live shop foreman can afford to be without this book.

PERSONALS

M. Marea has resigned as master mechanic of the Toledo, St. Louis & Western R. R.

William Sharp has been appointed general car inspector of Chicago, Burlington & Quincy R. R.

R. H. Lanham has been appointed master mechanic of the Missouri Pacific Ry., with headquarters at Poplar Bluff.

F. C. Moeller has been appointed night roundhouse foreman of the Rock Island Lines at Silvis, Ill., in place of J. Fitzgerald, promoted.

W. O. Morton has been appointed night roundhouse foreman, Rock Island Lines, at Burr Oak, Ill., succeeding William Glenn, promoted.

L. L. Ulrey has been appointed foreman of the air brake department of the Chicago & Eastern Illinois Ry., with headquarters at Oaklawn, Ill.

J. Fitzgerald has been appointed machine foreman at the Forty-seventh street shops, Chicago, Rock Island Lines, succeeding George Stone, promoted.

Walter H. Donley has been appointed master mechanic of the Illinois Central R. R., with office at East St. Louis, Ill., succeeding F. G. Colwell, resigned.

W. W. Calder has been appointed general car foreman of the Baltimore & Ohio Southwestern R. R., with office at Washington, Ind., succeeding H. Marsh.

W. A. Curley, foreman of the Missouri Pacific Ry. at Poplar Bluff, Mo., has been appointed master mechanic, with office at Ferriday, La., in place of G. W. French.

D. W. Cross has been appointed acting master mechanic of the Toledo, St. Louis & Western R. R., with headquarters at Frankfort, Ind., to succeed M. Marea, resigned.

A. A. McGregor has been appointed assistant master mechanic of the Louisville & Nashville R. R., with headquarters at Evansville, Ind., succeeding J. B. Huff, deceased.

George Usherwood has been appointed supervisor of boilers of the New York Central & Hudson River R. R., with office at West Albany, succeeding F. H. Linderman, promoted.

G. W. French, master mechanic of the Missouri Pacific Ry., with office at Ferriday, La., has been transferred to Paragould, Ark., as master mechanic, succeeding R. H. Lanham.

F. G. Colwell has been appointed master mechanic of the Buffalo division of the Delaware, Lackawanna & Western R. R., with office at East Buffalo, N. Y., succeeding B. H. Hawkins, resigned.

G. F. Hess has been appointed superintendent of machinery of the Kansas City Southern Ry. and the Arkansas Western Ry., with headquarters at Kansas City, Mo., succeeding J. W. Small, resigned.

N. S. Brooks has been appointed general foreman of the Baltimore & Ohio Southwestern R. R., with headquarters at Storrs, Cincinnati, succeeding W. F. Hayes, resigned on account of ill health.

P. H. Reeves, motive power inspector of the Baltimore & Ohio Southwestern R. R., at Cincinnati, Ohio, has been appointed master mechanic, with office at Chillicothe, Ohio, succeeding George F. Hess, resigned.

WILLIAM E. ROCKFELLOW, general car foreman of the New York Central & Hudson River R. R., has been appointed superintendent of the car department of the St. Lawrence and Ontario divisions, with office at Oswego, N. Y.

H. A. Witzig has been appointed master mechanic of the Missouri Southern Ry., with office at Leeper, Mo., in charge of shops and rolling stock, succeeding to the duties of Thomas Goulding, superintendent of motive power, resigned.

H. Marsh, for seven years general car foreman of the Baltimore & Ohio Southwestern R. R., at Washington, Ind., has been appointed general car foreman of the Iowa Central Ry., with headquarters at Marshalltown, Ia., succeeding W. E. Looney, resigned.

F. A. LINDERMAN, supervisor of boilers of the New York Central & Hudson River R. R. at West Albany, N. Y., has been appointed district superintendent of motive power of the Ontario and St. Lawrence divisions, with office at Oswego, succeeding J. O. Bradeen, resigned.

A. S. Abbott, master mechanic of the St. Louis & San Francisco Ry., at Sapulpa, Okla., has been appointed mechanical superintendent of the First district, and J. Foster, master mechanic at Kansas City, Mo., has been appointed mechanical superintendent of the Second district, both with offices at Springfield.

W. O. Thompson, master car builder of the New York Central & Hudson River R. R., at East Buffalo, N. Y., has had his authority extended and is now in charge of the territory west of Syracuse, including the St. Lawrence, Ontario and Pennsylvania divisions, and G. E. Carson, master car builder, at West Albany, has had his authority extended and is now in charge of the territory east of Syracuse, including the Hudson, Harlem and Putnam divisions.

FRANCIS D. CASANAVE, who, in the capacity of special agent, represented the Pennsylvania R. R., in charge of the locomotive testing plant at the World's Fair at St. Louis, in 1904, died recently at Escot, France. Mr. Casanave was born in France in 1843 and began his railroad career as an apprentice in the shops of the Pennsylvania R. R. at Altoona in 1862. After various promotions he became assistant master mechanic of the Altoona machine shops in 1876, in which capacity he served until 1881, when he became master mechanic of the Pennsylvania Co.'s shops at Ft. Wayne, Ind. In 1887 he was made superintendent of motive power of the Northwest system, Pennsylvania Lines West. He remained in this position until 1893, when he became general superintendent of motive power of the Lines East, serving in that capacity until 1901, from which date until 1903 he was general superintendent of motive power of the Baltimore & Ohio at Baltimore, Md. Mr. Casanave retired from active participation in railroad affairs at the conclusion of his special commission with the Pennsylvania R. R. in 1905.

CATALOGS

AUTOMATIC STOP VALVE.—A valve designed to automatically stop the supply of oil to the burners in case of any unusual conditions is illustrated in a leaflet sent out by the Rockwell Furnace Co., 26 Cortlandt Street, New York. It is called the Lalor Automatic Stop Valve.

WATER WEIGHER.—Elsewhere in this issue will be found an illustrated description of the Kennicott water weigher. This apparatus has been made the subject of Bulletin No. 38 from the Kennicott Co., Chicago Heights, Ill., where excellent colored illustrations clearly show its operation. Drawings are given showing several different styles.

GAS ELECTRIC MOTOR CAR.—The General Electric Company has just issued a very attractive publication devoted to a detailed description of its double truck type of gas-electric car. The publication is elaborately illustrated, and contains considerable data relative to the subject. It includes plans and elevations of cars of various sizes. The number of the bulletin is 4855.

ALTERNATING CURRENT GENERATORS.—Bulletin No. 481 issued by the Triumph Electric Co., Cincinnati, Ohio, contains some very interesting information on the subject of direct connected alternating current generators. Illustrations showing details of construction are accompanied by full description and discussion of the reasons for the recommended practice shown.

TURRET LATHES.—A booklet being sent out by the Gisholt Machine Co., Madison, Wis., is largely devoted to illustrating the surprising range of work which the turret lathe is capable of performing. Boring, turning, facing, threading and cutting operations of a difficult nature are found in the examples, in many cases on the same piece where several operations were performed simultaneously.

STEAM TURBINES.—In Catalog No. 19 received from the Kerr Turbine Co., Wellsville, N. Y., is given a complete illustrated description of the Kerr turbine, covering the principles and theory and operation as well as the features of construction. These turbines are made in sizes from 2 to 600 horsepower, using from two to eight stages. They are designed on the steam jet principle, with buckets which act very similar to those in a Pelton water wheel.

SMALL TOOLS.—Catalog No. 6 from Pratt & Whitney Co., Hartford, Conn., is devoted to excellent illustrations and full information, including prices of the complete line of small tools manufactured by it. The 248 page book is divided into sections, each devoted to a particular tool as follows: Taps, dies, milling cutters, reamers, punches, drills and miscellaneous tools. Valuable tables of dimensions of screw threads, etc., and a complete index occupy the last 30 pages.

HEAVY LATHES.—A catalog conforming to the excellent character of its former publications is being issued by Niles-Bement-Pond Co., 111 Broadway, New York, and is devoted entirely to illustrating large size lathes by large photographs, accompanied by brief descriptive matter. Pond lathes are shown in sizes from 24 to 72 inch swing in either of three styles of drive. Bement lathes with swings from 84 inches up occupy another section. Many new features are evident in these machines.

ELECTRICAL MACHINERY.—An attractive publication recently issued by the General Electric Company on the subject of Motor-Generator Sets contains brief descriptions of generator sets of different styles and sizes. These sets are made up of various combinations of alternating and direct current generators and motors, and range in capacity from 95 kw. to over 7,000 kw. The number of the bulletin is 4849. The same company has also just revised its bulletin devoted to Single-Phase Repulsion Motors. This bulletin is numbered 4858.

TOOL STEEL.—Jessop carbon and high speed tool steels are known throughout the world and the makers endeavor to maintain their reputation by keeping in the forefront in the developments in this class of material. A booklet just being issued from the principal American warehouse, 91 John St., New York, explains the principle on which all Jessop steels are made and gives full directions for properly working each kind. Tables of prices, extra sizes, and lists of different shapes of both tool and other steels are included. A table at the back of the catalog gives the temperature correponding to different colors of steel.

STORAGE BATTERIES.—"The Electrical Installations in the Detroit River Tunnel Plant" is the title of a new 12 page bulletin just issued by the Gould Storage Battery Co., 341 Fifth Avenue, New York. This bulletin describes the Gould battery and allied regulating apparatus by means of which current from the Detroit Edison Company's plant is made to pull Michigan Central trains through the new Detroit River Tunnel. The engineering in connection with this installation is unusual and of special interest to those having excessive peak loads.

NOTES

OFFICIAL GUIDE.—The offices of the National Railway Publication Company, publishers of *The Official Railway Guide*, have been removed from 24 Park Place to 75 Church Street, New York City.

PRESSED STEEL CAR CO.—N. S. Reeder, Vice-President of the Western Steel Car & Foundry Company, Chicago, Ill., has been elected Second Vice-President of the Pressed Steel Car Company. Mr. Reeder will continue his Chicago location.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO.—Edwin M. Herr, who was elected President of the Westinghouse Electric & Manufacturing Company at a meeting of the board of directors held in New York August 1, was born in Lancaster, Pa., May 3, 1860. Upon completion of a common school course, he was given the position of telegraph operator on the Kansas Pacific Railroad, with which Company he remained for two years. In 1881 he entered the Sheffield Scientific School of Yale, graduating in the class of 1884, and worked as an apprentice in the shops of the Pennsylvania Railroad Company at Altoona, Pa., during the two summer vacations. From 1884 to 1885 he was an apprentice at the West Milwaukee shops of the Chicago, Milwaukee & St. Paul Railroad. He then went to the Chicago, Burlington & Quincy Railroad Company as a draughtsman in the mechanical engineer's office, and afterwards became Assistant Engineer of Tests, and was promoted from this position to Engineer of Tests on this road at Aurora, Ill. From 1887 to 1889 he was Superintendent of Telegraphy, and from 1889 to 1890 Division Superintendent of this road. From 1890 to 1892 he was Division Master Mechanic of the Chicago, Milwaukee & St. Paul Railroad at West Milwaukee, and for the next two years was Superintendent of the Grant Locomotive Works at Chicago. From 1895 to 1897 he was Superintendent of Motive Power and Machinery of the Chicago & Northwestern Railroad, and from June 1, 1897, to September 10, 1898, he held the same position with the Northern Pacific Railroad. On September 10, 1898, he became Assistant General Manager of the Westinghouse Air Brake Company at Wilmerding, Pa. He was promoted to the position of General Manager on November 1, 1899, which position he held until June 1, 1905, when he was elected First Vice-President.

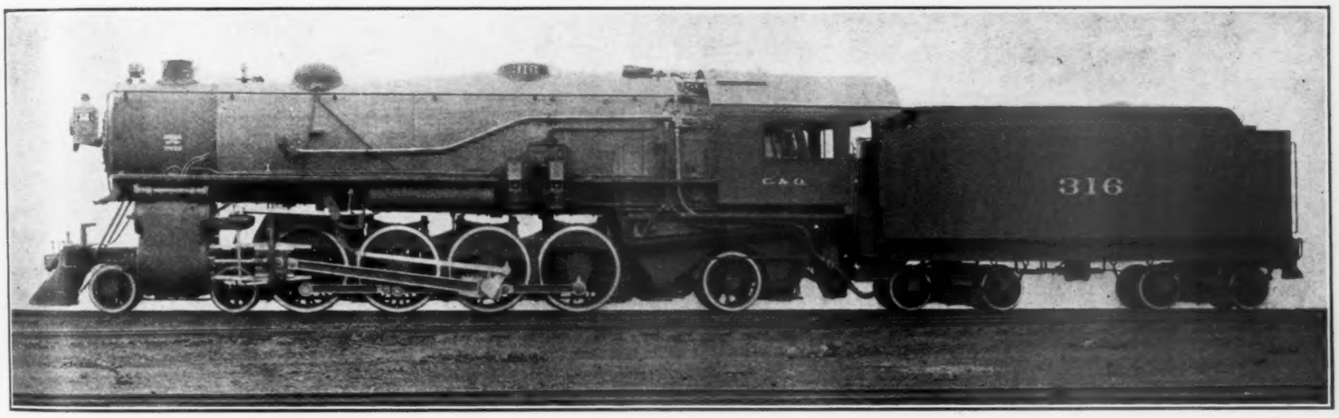
The Mountain (4-8-2) Type Passenger Locomotive

CHESAPEAKE & OHIO RAILWAY.

A SIMPLE PASSENGER LOCOMOTIVE WEIGHING 330,000 LBS. TOTAL WITH 239,000 LBS. ON FOUR PAIRS OF DRIVERS HAS BEEN DESIGNED AND AN ORDER OF TWO BUILT FOR THE CHESAPEAKE & OHIO RAILWAY BY THE AMERICAN LOCOMOTIVE COMPANY. THIS DESIGN NOT ONLY HOLDS THE RECORD FOR SIZE AND POWER OF SIMPLE LOCOMOTIVES, BUT IS THE FIRST IN REGULAR SERVICE IN THIS COUNTRY TO INCORPORATE THE SCREW REVERSE GEAR.

On the Clifton Forge Division of the Chesapeake & Ohio Railway the Pacific type locomotives in use, which have 22 by 28 in. cylinders, 72 in. drivers, 200 lbs. steam pressure, total heating surface of 3,737 sq. ft. and weigh 216,000 lbs. total, with 157,700 lbs. on drivers, are able to maintain the schedule of 25.5 m. p. h. west bound and 33 m. p. h. east bound, with a maximum of six cars weighing 350 tons. Since the traffic on these trains frequently requires ten or twelve cars it has been necessary to double head with great regularity.

Recently two locomotives have been put into service, one of which will comfortably handle a twelve-car train over this division on the same schedule. As can be readily surmised, these locomotives are unusually powerful machines and as a matter of fact they not only are the largest passenger locomotives, excepting the Mallet of the Santa Fe, but are also the largest and most powerful simple locomotives ever built.



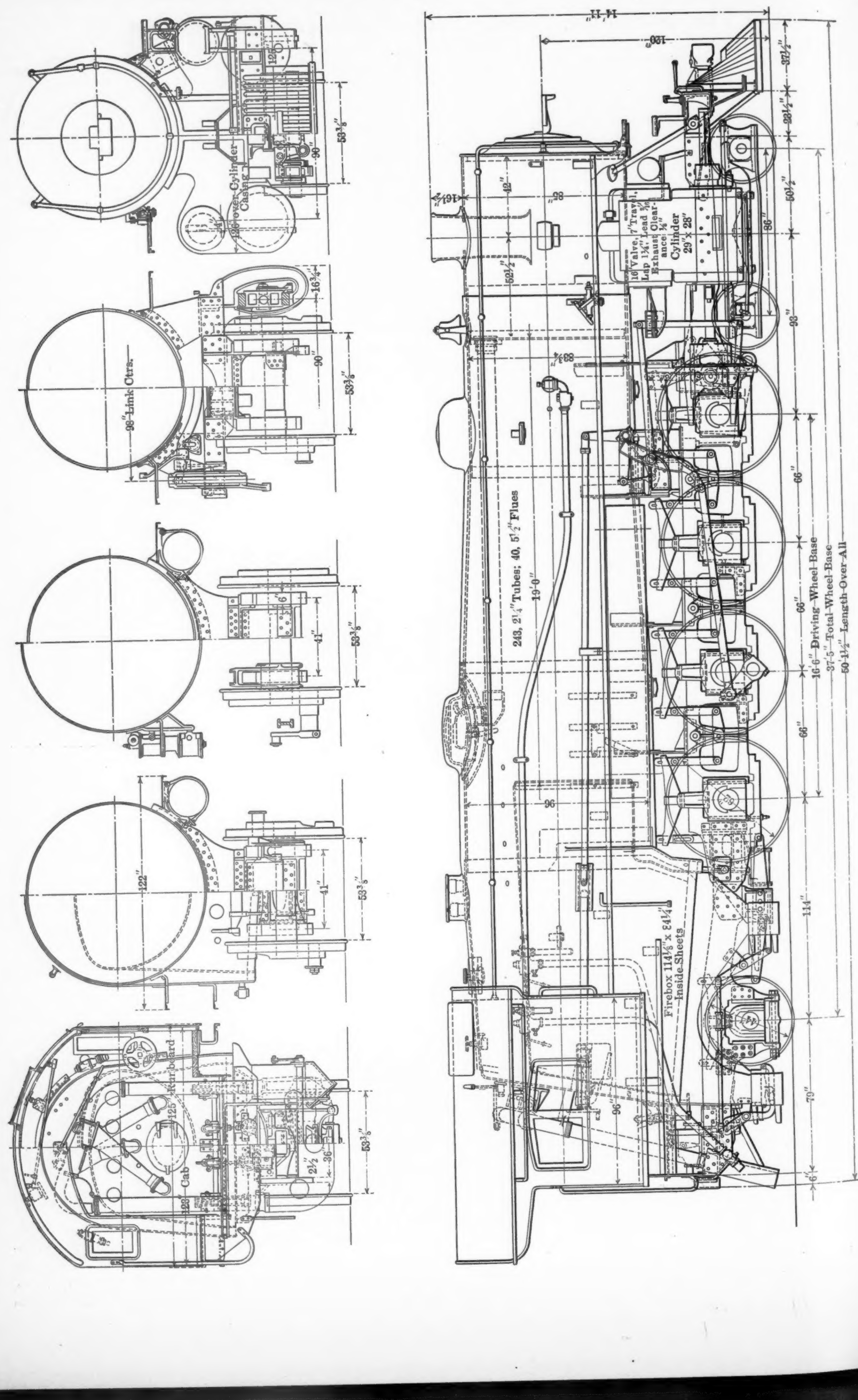
LARGEST SIMPLE LOCOMOTIVE, INTRODUCING A NEW TYPE OF WHEEL ARRANGEMENT.

The engineers of the American Locomotive Company, after making a careful and extended study of all conditions, etc., found the service could be performed by a simple locomotive, but that it would be necessary to introduce a new wheel arrangement, viz., 4-8-2 type. This type has been named by J. F. Walsh, superintendent of motive power, the "mountain" type. The design was prepared by the builders in collaboration with the motive power officials of the company and even a cursory examination of the illustrations and data given herewith will show it to be worthy of the admiration of every champion of progressive, sound, and clean-cut locomotive design.

The great power of these locomotives is best indicated by comparison with the next largest simple locomotive on our records and with the class K3 Pacific type passenger locomotive on the New York Central Lines. The table in the next column will permit of such comparison.

Since going into service these two locomotives have proven to be all that was expected. They are at present assigned regularly to trains 2, 3, 4 and 5, the odd numbers being west bound, which have the schedules mentioned above of 25.5 m. p. h. west bound and 33 m. p. h. east bound, including stops, of which No. 3 makes four, No. 5 seven, No. 4 two, and No. 2 two to five. As shown on the profile, the grades are very heavy in both directions, the worst being against west bound traffic. On the 14 mile 75 ft. grade from Meechum's River to Afton there are uncompensated curves of 10 degs., giving an equivalent grade of 1.82 per cent. This grade and the 7 mile, 80 ft. grade, by which the summit of the division is reached, are the most difficult parts of the road and the new locomotives are designed to give sufficient power to maintain a speed on this section of 25 m. p. h. with a 600 ton train, and as a matter of fact they have considerably exceeded it. On a number of days since being in regular service, both of these locomotives have made the run from Charlottesville to Clifton Forge, with trains of approximately 700 tons, in considerably better than schedule time. In one case, with a train of 636 tons, 21 minutes was made up over the division and in another case, with a train of 700 tons, eight minutes was made up. On the Allegheny District of the Hinton Division, from Hinton to Clifton Forge, a distance of 80 miles, many similar records have been made. In the matter of speed the locomotives have shown themselves to be unusually capable. On one occasion, with a 10-car train, 2.4 miles, over a level track, was negotiated in two minutes flat, giving a speed of 72 m. p. h. On July 13, with a light train of seven coaches, which had a schedule of 3 hrs. and 20 min. over the division, the run was made in 2 hrs. and 39 min., 29 stops being made, and speeds of approximately 58 m. p. h. being obtained between stops. As an example of the sustained power of the locomotive

	C. & O.	B. & O.	N. Y. .C
Type	4-8-2	2-8-2	4-6-2
Total weight, lbs.	330,000	274,600	269,000
Weight on drivers, lbs.	239,000	219,000	171,500
Average weight per driving axle, lbs.	59,750	54,750	57,167
Tractive effort, lbs.	58,000	50,200	30,900
Cylinders, in.	29x28	24x32	23½x26
Steam pressure, lbs.	180	205	200
Diam. drivers, in.	62	64	79
Diam. of boiler at front ring, in.	83¾	78	72
Number and size of tubes	243-2¼	389-2¼	175-2¼
	40-5½	.....	32-5½
Evaporative heating surface, total sq. ft.	4,132	5,017	3,424.1
Superheater heating surface, sq. ft.	845	.....	765
Grate area, sq. ft.	66.7	70	56.5
Reference for description in this JOURNAL	....	Apr. '11	Apr. '11



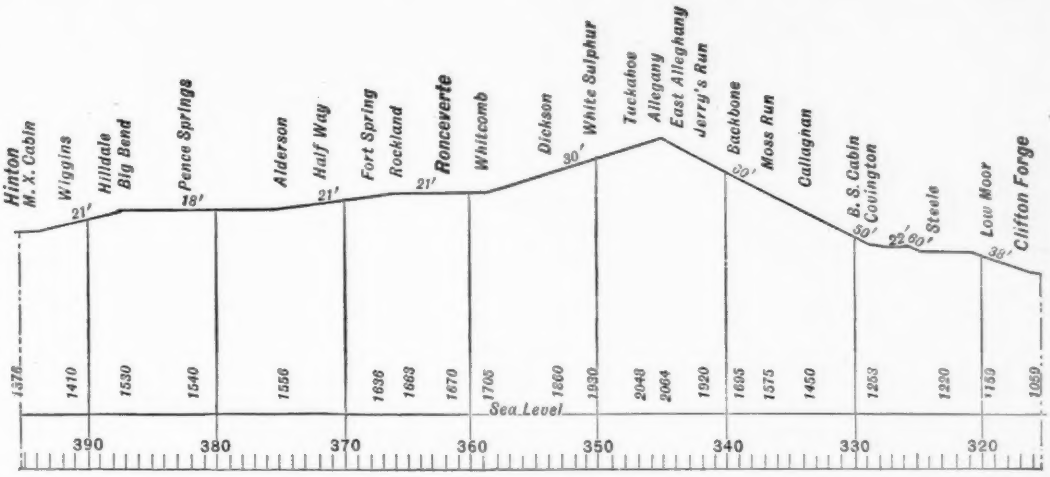
THE "MOUNTAIN" TYPE PASSENGER LOCOMOTIVE FOR CHESAPEAKE AND OHIO RAILWAY.

performance in handling a train of 4,200 tons on a grade of 15 ft. to the mile, at the rate of 23.5 m. p. h., is striking. In fact, in all respects the work of the locomotives in service have more than met the expectations of the railway company and the builders.

BOILER.

No better proof can be given of the boiler capacity of this locomotive than the work it did in hauling the train of 4,200 tons mentioned above. Assuming a resistance of 9 lbs. per ton, which is probably conservative, the draw bar pull required for this train would be 37,800 lbs., and at 23.5 miles per hour this would give a draw bar h.p. of 2,350 and an indicated h.p. of about 2,600 with a 90 per cent. machine efficiency. At a water rate of 21 lbs. per h.p. hour this requires the evaporation of 54,810 lbs. of water per hour or about 13¼ lbs. per square foot of heating surface per hour. At a rate of 3¼ lbs. of coal per draw bar h.p. this speed sustained on this grade would require about 7,600 lbs. of coal per hour or 114 lbs. per square foot of grate. This, of course, puts the locomotive out of the hand-fired class and it is only the stoker that permits it to develop so large a boiler capactiy.

In construction the boiler does not differ particularly from customary design,, being of the conical type 83¾ in. in diameter at the front ring and 96 in. diameter at the largest point, having 19 ft. tubes and a combustion chamber of 3 ft. 6 in. in length. There are 243 2¼ in. tubes and 40 5½ in. tubes, giving an evaporative heating surface of 3,795 sq. ft., which, together with the firebox, gives a total evaporative heating surface of 4,132 sq. ft., or about the same as has been used on the larger consolidation locomotives and many of the large Pacific type engines which are not equipped with superheaters. It is of the radial stayed type having a firebox 84¼ in. wide, the inner firebox sheet sloping slightly inward. One of the detailed illustrations shows the construction at the dome, where it is seen that the inner reinforcing sheet has been flanged downward to a depth of about 5 in. at the center, acting as an interior extension to the dome proper and assisting in obtaining dryer steam. A 9 in. dry pipe with a throttle of corresponding size has been applied on these locomotives.

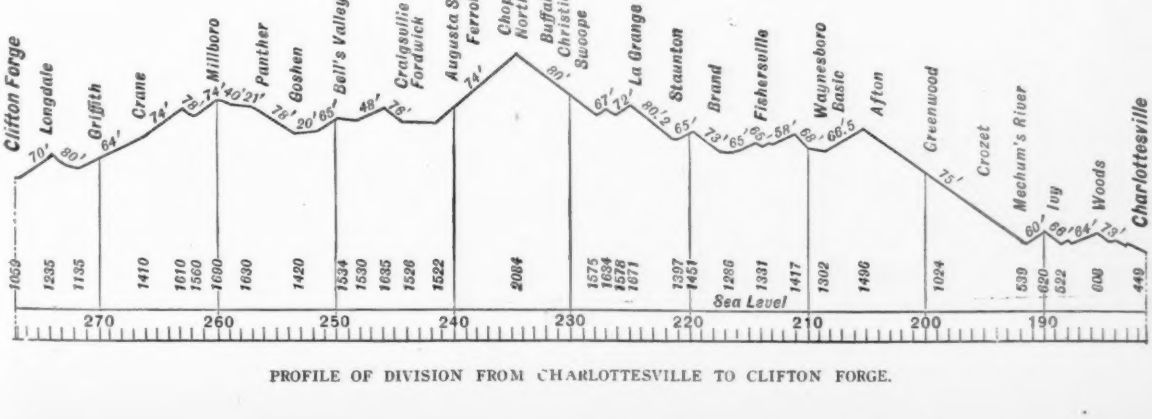


PROFILE OF DIVISION FROM CLIFTON FORGE TO HINTON.

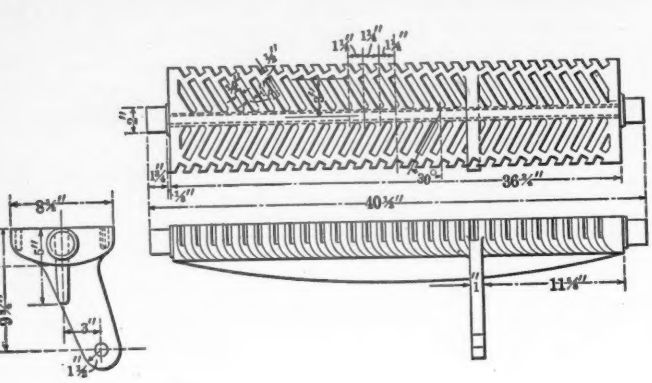
The superheater is of the regular Schmidt design, furnished by the Locomotive Superheater Company. It has 40 elements, each being on the double loop system formed of four lines of 1 7/16 in. tubes, No. 9 B. W. G. in thickness. These elements extend to a point 24 in. from the back tube sheet and should deliver steam at the steam chest with a temperature of from 600 to 625 degs. F. The heating surface of 845 sq. ft. does not include the surface of the header. There is little doubt in the minds of those familiar with this locomotive but that the superheater is largely responsible for the success of the engine and that without it it would have been practically impossible to have obtained this amount of power with a simple locomotive.

One of the illustrations shows the grates, which are of the rocking type in four sections and are inclined slightly downward toward the center. This has been done for the purpose of getting the greatest distance possible between the grate level and the bottom of the combustion chamber, since it is necessary to build up a very heavy fire before starting on some of the heavier grades.

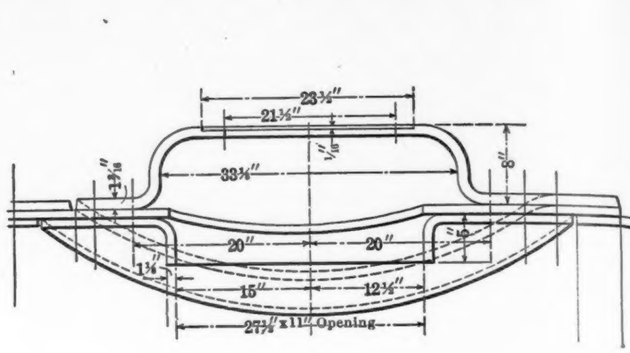
The grates are shaken by power, the whole apparatus being furnished by the Franklin Railway Supply Company. The construction is such that any one of the four sections can be shaken independently or all of them together, either by hand or by power, as desired. The arrangement for doing this is shown in the illustrations and will be seen to consist of a shaft across the back head of the boiler just above the cab floor, to which are connected the four levers attached to the arms from the



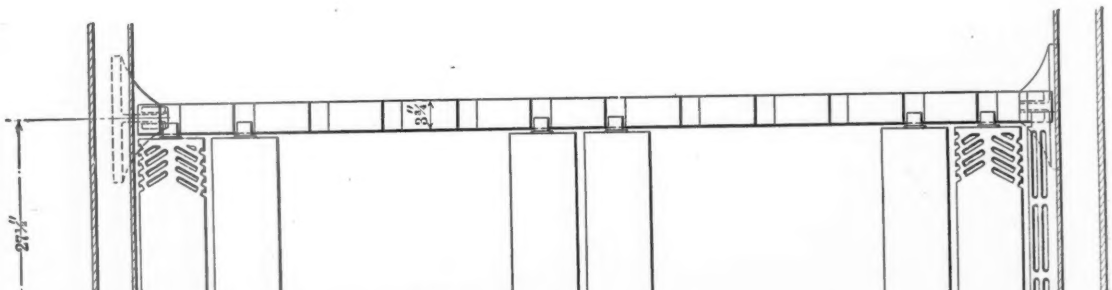
PROFILE OF DIVISION FROM CHARLOTTESVILLE TO CLIFTON FORGE.

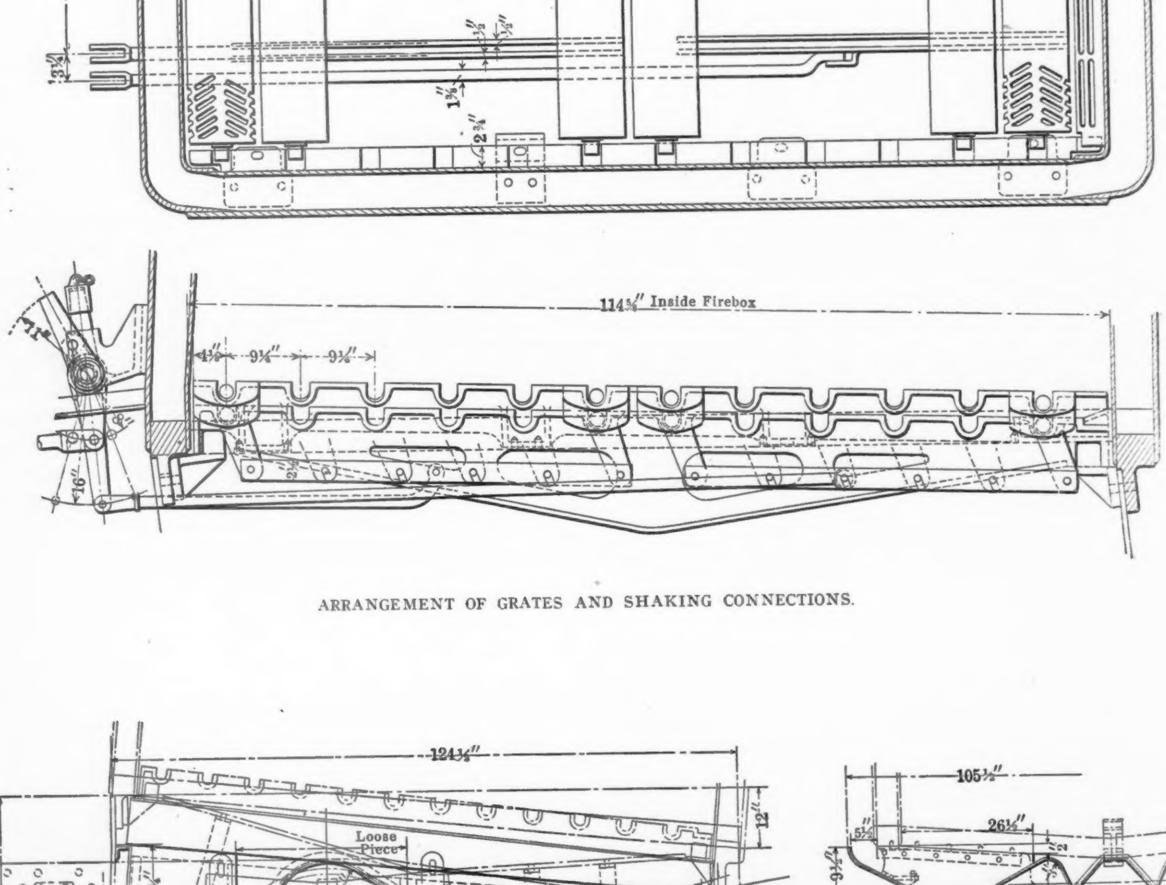


DETAIL OF GRATE BAR.

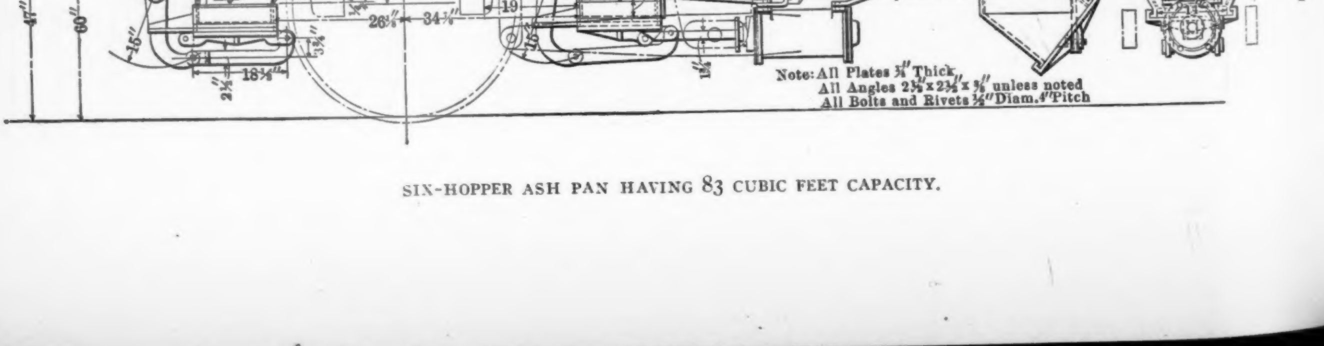


CONSTRUCTION OF BOILER AT DOME.



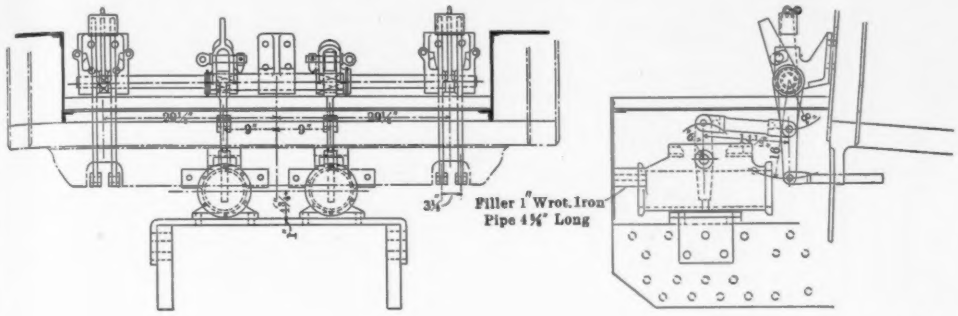


ARRANGEMENT OF GRATES AND SHAKING CONNECTIONS.



SIX-HOPPER ASH PAN HAVING 83 CUBIC FEET CAPACITY.

different sections of the grates. These shaking levers have a loose fit on the shaft and either of them can be operated by hand. Between each pair it will be seen that there is an arm extending upward from the shaft, on which it has a squared fit and a cap is provided which can be slipped over the top of this and one or both of the shaker levers. Thus when the shaft is oscillated the movement will be communicated to as many of the shaker levers as desired. Below the cab floor there are two 6 in. cylinders, each fitted with a double piston having a slot in its center into which extends, through an opening in the side of the cylinder, one end of the rocker arm connected through a link to an arm loosely carried on the shaft. Around the upper end of this rocker arm is a U-shaped forging, having a square fit on the shaft and provided with a key, which passes through an opening in the loosely supported arm. Thus when more than one section of the grates are to be shaken by hand the pins from the power operating gear are removed and the caps put over the tops of such sections as it is desired to shake and the whole arm is oscillated by hand. When the power gear is used the pins are inserted and the cylinders oscillate the shaft, shaking such sections of the grates as are desired. The control of the shaking apparatus is located in a double valve with two operating levers, which is placed on the back head of the boiler, the pipe connection being such that steam is admitted to one and the other end of the cylinders as the operating handle is thrown from one side to the other. In case steam pressure is not available air pressure can be used for operating the apparatus.

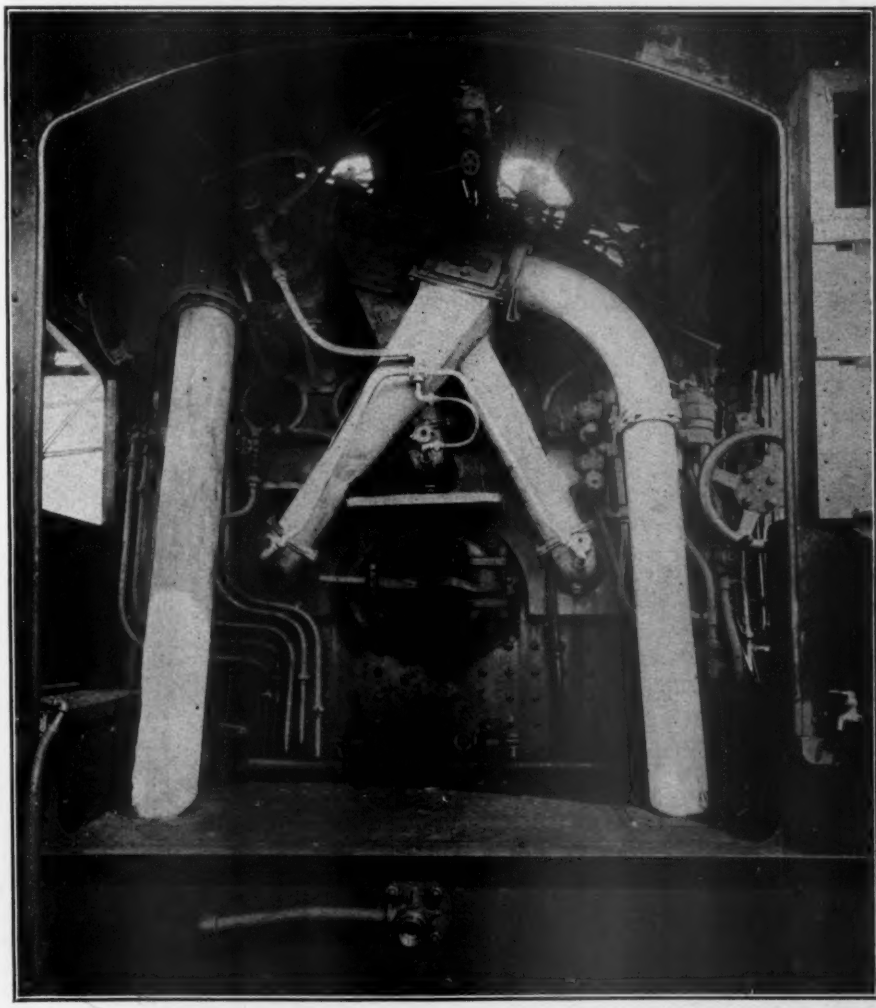


POWER GRATE SHAKER.

As can be readily seen by the amount of coal burned when the locomotive is working at its full capacity, it is very necessary to have a maximum ash pan capacity if runs of any length are to be made, therefore the designers have evolved an unusual and excellent arrangement in this case, which consists of six separate hoppers, all of them being dumped from one power operated gear. This pan has a capacity of nearly 83 cu. ft. as compared with about 55 cu. ft. for the ash pan on a large Pacific type locomotive. The details of the construction of the pan are clearly shown in one of the illustrations. It will be seen that it is entirely self-clearing and that a cylinder of large size is provided for moving the slides. A novelty is introduced in connection with the air inlets at the mud rings, where in place of the ordinary vertical opening underneath the ring covered with netting, the pan in this case has been extended out 5½ in. from the mud ring and brought up to the same level, leaving a horizontal opening of this dimension on both sides. As is shown in the photograph the overflow from the injectors has been split and discharges into the front and back hoppers of the pan at both sides. Since, of course, the locomotives operate in a mild climate this arrangement is feasible and advisable.

The Street locomotive stoker applied to these locomotives differs slightly from that illustrated and described on page 232 of the June issue. This change being in connection with the passage from the conveyors to the distributing nozzles. The stoker in other respects is the same as that shown. In this case the coal upon being emptied from the bucket conveyor falls upon a screen, which can be rotated to get different size openings to correspond with the quality of coal being used, and such coal as will pass through the openings falls into the passage to the center nozzle, the finer coal thus all being put into the firebox at the back end. Such coal as will not pass through the screen slides downward and is discharged into the two side pipes. A distributing device, arranged across the engine so that the rolling of the locomotive or the angularity of the track will not affect it, controls the distribution between these two nozzles. One of the illustrations shows a view in the cab which clearly illustrates this arrangement.

In the front end, the arrangement has been greatly simplified by the use of the steam pipes passing out through the side of the smoke box to the top of the steam chest. A comparatively low exhaust nozzle having a tip with a minimum diameter of 7⅛ in. is used in connection with a long straight interior extension

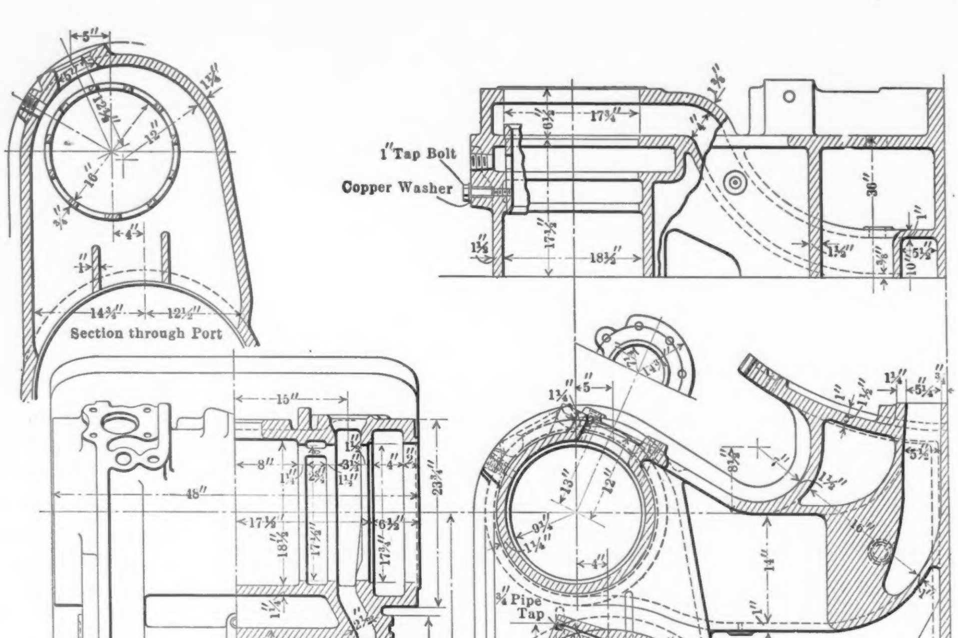


VIEW IN CAB, SHOWING ARRANGEMENT OF STREET STOKER AND THE SCREW REVERSE GEAR.

to the 20 inch stack. The front tube sheet is set well back from the center of the stack, giving ample room for the superheater.

Cylinders.

Simple cylinders 29 in. in diameter by 28 in. stroke are the largest ever applied to a passenger locomotive and the largest in diameter of any simple locomotive on our records. An inspection of the illustration showing the details of construction indicates that no great difficulty was experienced in designing them. The customary 90 in. centers have been obtained and because of the use of the outside steam pipes, eliminating any necessity for entrance steam passages in the saddle, the design is greatly simplified and improved Sixteen-inch piston valves are employed and the standard by-pass valve of the builders has been applied. In this case a small extra piston has been provided in the by-pass valves, acting as a cushion and preventing all slamming of the valves against their seats. It will be seen that arrangements are made for the admission of oil directly to the top of cylinder at the center.



DETAILS OF CYLINDER HAVING STEAM ADMISSION AT THE TOP OF THE STEAM CHEST.

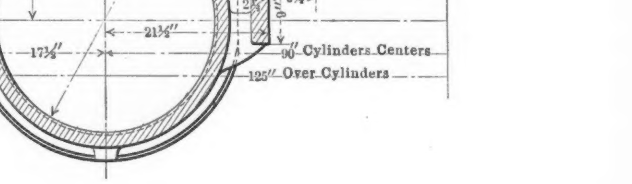
The piston rod is 4½ in. in diameter and has an extension through the front cylinder head where a suitable bearing and packing gland is provided.

Valve Gear.

These locomotives present the first example in regular service in this country of the use of the straightforward hand-operated screw reverse gear. The construction of this gear is shown in one of the illustrations and it will be seen that it consists simply of a steel block sliding in guides attached to the side of the boiler and threaded to receive a shaft having triple thread. 1⅛ in. pitch. It also carries an extension threaded to receive a 3 in. extra heavy iron pipe, which is carried out through the front of the cab to another block in guides to which is pinned the reach rod. A steel shaft threaded to suit the block passes through it and carries the operating wheel at the back end. Where this shaft takes a bearing in the supporting casting ball thrust bearings have been provided on either side. On this shaft is an extending ring with notches to the number of ten and a latch is provided on the upper side which, by falling into one of the notches, locks the gear in place. Since there are ten of these notches and a complete revoluton of the wheel gives a movement of 1⅛ in., it will be seen that each notch corresponds to less than ⅛ in. movement of the reach rod. A scale is secured to the top of the upper guide and a pointer, from the sliding block, indicates on it the number of inches cut-off for any particular position. This scale is stamped after the gear is in place and directly from the measurements made on the valve stem. It requires about 10 turns of the wheel to throw the engine from full gear forward to full gear backward.

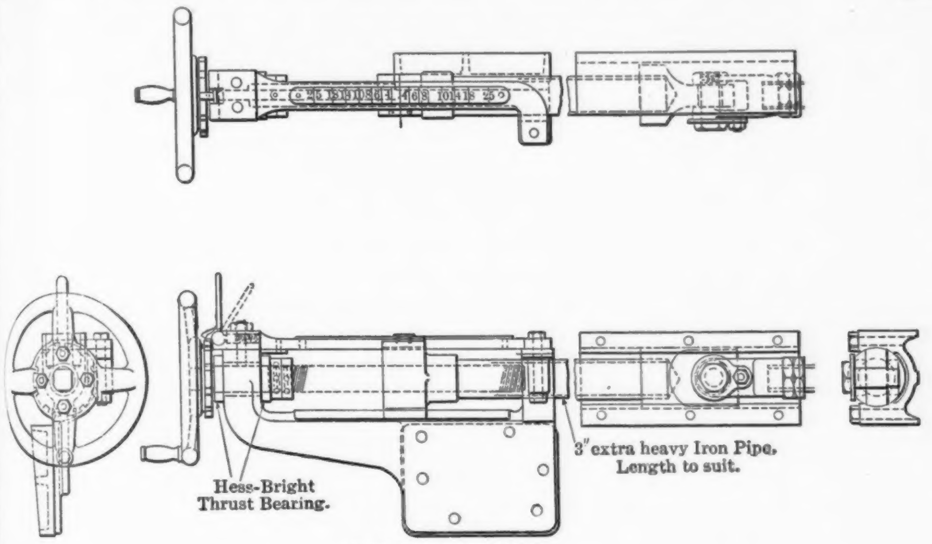
A new construction is noticed in connection with the guide carrying the valve stem crosshead. This is shown in detail below and is arranged so that all lost motion and wear can be readily taken up without dismantling the gear. The gear is arranged to give a 7 in. valve travel and the valve has a 3/16 in. lead.

The frames, which are, of course, very heavy, are made of vanadium steel. Two 9½ in. pumps have been provided on the



ADJUSTABLE GUIDE FOR VALVE STEM CROSSHEAD.

left-hand side and two reservoirs, one 20½ by 150 in., and the other 20½ by 90 in., are swung under the running board. The cylinder cocks are operated by the Hancock pneumatic gear. The front and rear trucks, the latter being of the inside journal type, are of the builders' standard practice, which has been illustrated in these columns. It will be noticed that a small running board is provided underneath the cab on either side, with a suitable handhold, permitting access to the air pumps, check valves and other parts reached from the running board without passing though the cab. The tender is large, having a capacity for 9,000 gallons of water and 15 tons of coal. It is carried on trucks fitted with the Andrews cast steel side frame. The tender frame is built up of 13 in. channels.



SCREW REVERSE GEAR.

The general dimensions, weights and ratios are given in the following table:

GENERAL DATA.

Gauge	4 ft. 8½ ins.
Service	Passenger
Fuel	Bit. Coal
Tractive effort	58,000 lbs.
Weight in working order	330,000 lbs.
Weight on drivers	239,000 lbs.
Weight of engine and tender in working order	503,400 lbs.
Wheel base, driving	16 ft. 6 in.
Wheel base, total	37 ft. 5 in.
Wheel base, engine and tender	70 ft. 6 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.12
Total weight ÷ tractive effort	5.69
Tractive effort × diam. drivers ÷ total heating surface	870.00
Tractive effort × diam. drivers ÷ equivalent heating surface	666.00
Total heating surface ÷ grate area	61.90
Firebox heating surface ÷ total heating surface per cent	8.15
Weight on drivers ÷ total heating surface	57.90
Weight on drivers ÷ equivalent heating surface	44.30
Total weight ÷ total heating surface	80.00
Total weight ÷ equivalent heating surface	61.00
Volume both cylinders, cu. ft	21.40
Total heating surface ÷ vol. cylinders	193.00
Equivalent heating surface ÷ vol. cyls	252.00
Grate area ÷ vol. cyls	3.12

CYLINDERS.

Kind	Simple
Diameter and stroke	29 x 28 in.

VALVES

Kind	Piston
Diameter	16 in.
Greatest travel	7 in.
Outside lap	1¼ in.
Inside clearance	⅛ in.
Lead	3-16 in.

WHEELS.

Driving, diameter over tires	62 in.
Driving, thickness of tires	3 in.
Driving journals, main, diameter and length	11½ x 14 in.
Driving journals, others, diameter and length	10½ x 14 in.
Engine truck wheels, diameter	33 in.
Engine trucks, journals	6 x 12 in.
Trailing truck wheels, diameter	44 in.
Trailing truck, journals	9 x 14 in.

BOILER.

Style	Conical
Working pressure	180 lbs.
Outside diameter of first ring	83 ¾ in.
Firebox, length and width	114⅛ x 84¼ in.
Firebox plate, thickness	⅜ x ½ in.
Firebox, water space	F-5, S. & B-4½ in.
Tubes, number and outside diameter	243-2¼, 40-5½ in.
Tubes, length	19 ft.
Heating surface, tubes	3,795 sq. ft.
Heating surface, firebox	337 sq. ft.
Heating surface, total	4,132 sq. ft.
Superheater heating surface	845 sq. ft.
Grate area	66.7 sq. ft.
Smokestack, diameter	20 in.
Smokestack, height above rail	179 in.
Center of boiler above rail	120 in.

TENDER.

Frame	13 in. chan.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	9,000 gals.
Coal capacity	15 tons

THE TURBINE LOCOMOTIVE

The turbine locomotive is now being developed elsewhere than at Glasgow. A small locomotive fitted with specially designed turbines has been successfully tried at Milan. The peculiar feature of the turbine is the use of movable blades, which are operated in series. Four sets of such blades are used, and at high speed the steam strikes the first set of blades only, while at intermediate speeds two sets or three sets can come into play. The reversing mechanism is a special and unique feature of this motor. The rotors have two sets of blades which are of opposite curvature. When running in one direction the steam passes over the blades at the outer circumference from left to right; when running in the opposite direction steam passes over the other set of blades from right to left. In either case the loss of energy due to the blowing action of the second set of blades only amounts to a small fraction of the total, and the experiments show it to be 2 to 3 per cent. It is reported that this engine starts well under load both on curves and gradients, and that the consumption of steam has not exceeded 38 lbs. per horsepower hour when running in either direction.

Subjects at the General Foremen's Convention.—The Executive Committee of the International Railway General Foremen's Association has outlined the following subjects for discussion at next year's convention: "How Can Shop Foremen Best Promote Efficiency?" to be presented by William G. Reyer, general foreman, Nashville, Chattanooga and St. Louis, Nashville, Tenn. (this will be a continuation of the paper presented at the convention in 1910); "Shop Supervision and Local Conditions" to be presented by W. W. Scott, general foreman, Cincinnati, Hamilton and Dayton, Indianapolis, Ind.; "Shop Specialization, Work and Tools," by W. T. Gale, demonstrator, Chicago and Northwestern, Chicago; "Roundhouse Efficiency," by William Hall, shop foreman, Chicago and Northwestern, Escanaba, Mich. L. H. Bryan, Duluth and Iron Range, Two Harbors, Minn. is secretary of the association.

Santa Fe Scholarship.—Ture Tulien, machinist apprentice at Topeka, Kans., has been awarded the Santa Fe Armour scholarship. The Santa Fe Employees Magazine maintains a scholarship at the Armour Institute of Technology in Chicago, providing for four years free tuition to the Santa Fe apprentice making the highest marks during his four years apprenticeship. At present there are two apprentices at Armour.

Most of the Cuban Railways are in the hands of British companies. The total mileage is 2,170 miles. The leading railways are: The United Railways of Havana, with 710 miles; the Cuba Railroad, with 595 miles; the Cuban Central Railway, with 262 miles, and the Western Railway of Havana with 147 miles.

AN INTERESTING MACHINE TOOL CONVERSION.

It is a well-known fact that the conversion of a practically discarded machine tool of a certain class into one capable of productive and useful work in an entirely different field is considered by machine shop foremen generally as the crowning achievement of the trade, and there are very few foremen who have not experimented along this line, although not always with entire success. Instances abound in many of the older shops where worn out planers have been metamorphisized into

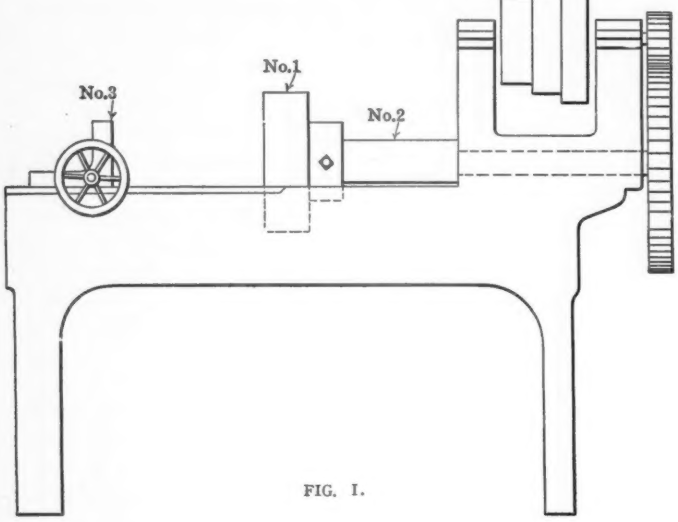


FIG. I.

quite adequate grinding machines for the truing of guides, etc., where lathes have even been changed into drill presses and shapers made to actually bore car brasses. Whether advisable or not, these changes are always of interest as a tribute at least to the ingenuity displayed in the conception.

The conversion of an old bolt cutter, as herein illustrated, to a thoroughly efficient pipe threading machine forcibly illustrates what may be done to preserve usefulness in a tool of practically no value other than scrap. This bolt cutter was a single-head affair, of a capacity sufficient to thread bolts up to 1¼ in. diameter, and which had been crowded out of service through the introduction of modern machines. The shop in question was in need of a pipe threading machine for pipe up to 1½ in.

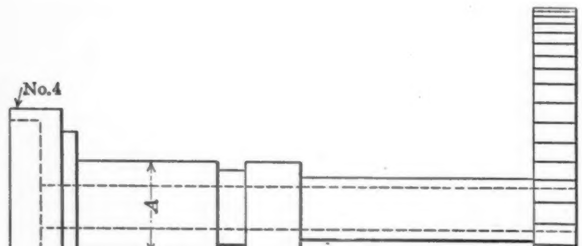


FIG. 2.

diameter, and being unable to secure the necessary appropriation for its purchase recourse was had to the old discard, and with very happy results.

Fig. 1 illustrates the assembled machine after having been changed over to include its new field of usefulness. The original die head that had been on spindle No. 2 was removed entirely, as well as the rigging which actuated its opening and closing, and the part marked No. 4 in Fig. 2 which was integral with the spindle was turned off to the size A. A new head, as shown in Fig. 3, was made from a suitable piece of cast iron. This was provided with a square countersink large enough to take in a 1½ in. pipe die, bushings, No. 5, being made for the smaller dies. Lugs, No. 6, and set screws, No. 7 serve to hold the bushings and dies firmly in place.

The vise of the carriage, No. 3, in Fig. 1 was also changed somewhat, this change being more clearly indicated in Fig. 4.

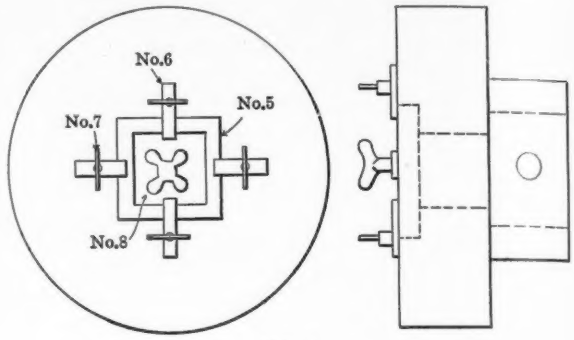


FIG. 3.

New jaws, No. 9, were made so that their shanks would fit in the original slots of the vise. These were, of course, made male and female, as shown in the above reference, this in order to clamp ¼ in. pipe as well as the 1½ in. size.

The remaining points of interest are clearly apparent in the illustrations and scarcely require further explanation, but some comment on the speed is advisable. As will be noted, the machine has a two-step cone and the pulleys were so proportioned that the spindle made 45 revolutions on the highest speed and 20 on the lowest, equivalent to a cutting speed of 12 feet per minute which left a clean-cut thread. The machine was also tried cutting thread on 1½ in. pipe on the fastest speed, that of 18 ft. per minute, but it was found that this resulted in a ragged thread. The pulleys were finally proportioned so that on the lowest cutting speed 14 ft. per minute was secured with 1½ in. pipe. The machine is in daily use in one of the large western railroad shops, and is considered to do the work with the best economy considering all factors.

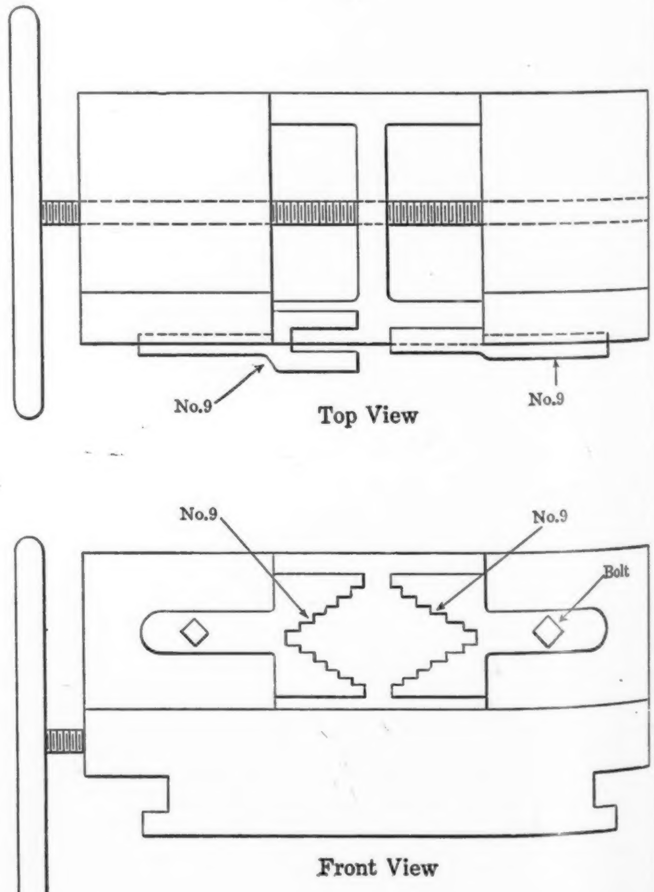


FIG. 4.

New Locomotive Terminal Facilities at Bloomington, Ill.

CHICAGO & ALTON RAILWAY

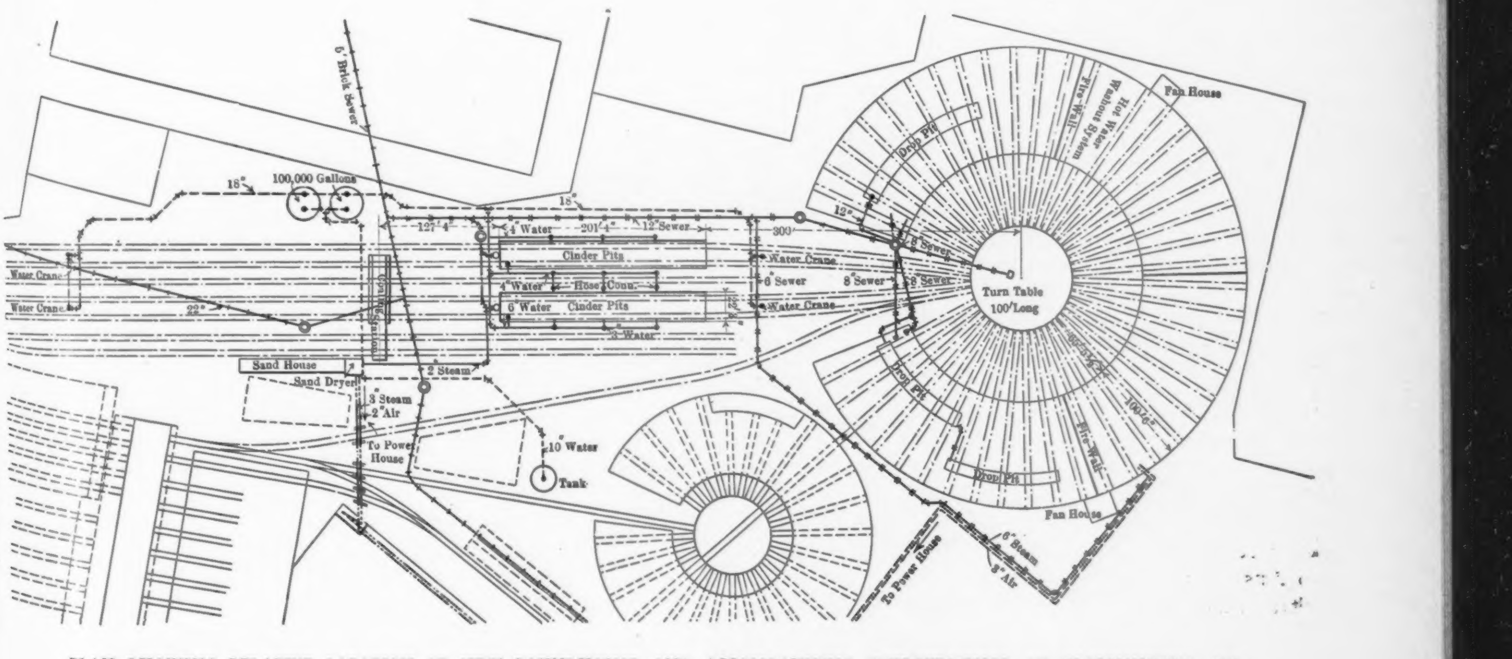
FOR THE THIRD TIME THE CHICAGO & ALTON RAILWAY HAS FOUND IT NECESSARY TO BUILD A LARGER ROUNDHOUSE, WITH ATTENDING FACILITIES, AT BLOOMINGTON, AND ARE NOW JUST PUTTING INTO SERVICE A 44-STALL ROUNDHOUSE, WITH MODERN COALING STATION AND CINDER PITS OF SUITABLE CAPACITY WHICH WAS DESIGNED AND BUILT BY WESTINGHOUSE, CHURCH, KERR & CO.

On new ground acquired for the purpose, adjacent to the main repair shop at Bloomington, Ill., the Chicago & Alton Railway has erected a very large roundhouse. It contains 44 stalls, is 100 ft. 6 in. between circular walls, and is provided with a 100 ft. turntable, together with two cinder pits serving four tracks, each being 201 ft. 4 in. in length, and a large mechanical coaling station, spanning four tracks, having a storage capacity of 525 tons. A large sand house, sand dryer, and necessary equipment, together with two 100,000 gallon water storage tanks, have also been constructed. The steam, air, electricity and water supply are obtained from the power house of the shops, which is not far distant.

The roundhouse structure outside of its size presents very few features of interest. The decision to have a distance of over 100 ft. between circular walls is no doubt a wise one, as is also the installing of a 100 ft. power operated turntable. The practically standard dimension for roundhouses has been in the neighborhood of 90 ft., and even with the present power, particularly in drop pit sections, it is often found necessary to leave the doors open or to remove the tender and back the locomotive in for work on certain drivers. At present every indication points to continual increase in length of locomotives, and it is not beyond reason to believe that a 90 ft. house will prove to be too small for convenient work in the not distant future.

In this case the roundhouse consists of brick pilasters in the outer circle, which measure about 5 ft. in width by 17 in. thick and are supported in a concrete foundation. Between each there is a brick wall 8½ in. thick carried up 4 ft. 3 in. above the floor level, above which the space between the pilasters and to the roof, a distance of 15 ft. 7 in., is window area formed of 18 sash in 6 vertical sections, the sash being arranged to slide vertically and being counterbalanced. The roof is of the flat wooden type and rises from 20 ft. 10 in. at the outer circle wall to 25 ft. 1¾ in. at the inner circle. It is covered with four-ply tar and felt roofing and is supported by three 10 by 10 in. wooden posts equally spaced on the interior and a 12 by 12 in. door post at the inner wall. The doors, arranged to swing outward, are of solid wood structure and there are 5 ft. lighting transoms above them. The whole house is divided into four sections by 13 in. fire walls giving ten pits in two sections and 12 in the other two. The tracks are at an angle of 7° 12′ and reach the turntable circle without the use of frogs.

Concrete has, of course, been liberally used throughout the structure, the floors, pits and foundations being of this material, as well as the turntable circle wall and foundation. The engine pits are shown in detail in the illustrations and will be seen to be particularly well designed. They are 77 ft. in length, there being a drop of 6 in. toward the inner circle for drainage, the maximum depth of pit being 3 ft. The side walls are made 2 ft. 4 in. in thickness, which gives a solid support for jacks on either side of the locomotive for the full length. A novelty is introduced at the outer end of the pits, where there is a depression in the concrete outside of each track rail 16 in. wide and 11 in. deep covered with a removable section of wooden flooring. This depression is 11 ft. in length and is provided for the convenient insertion of jacks under the bumper beams of low wheeled locomotives.

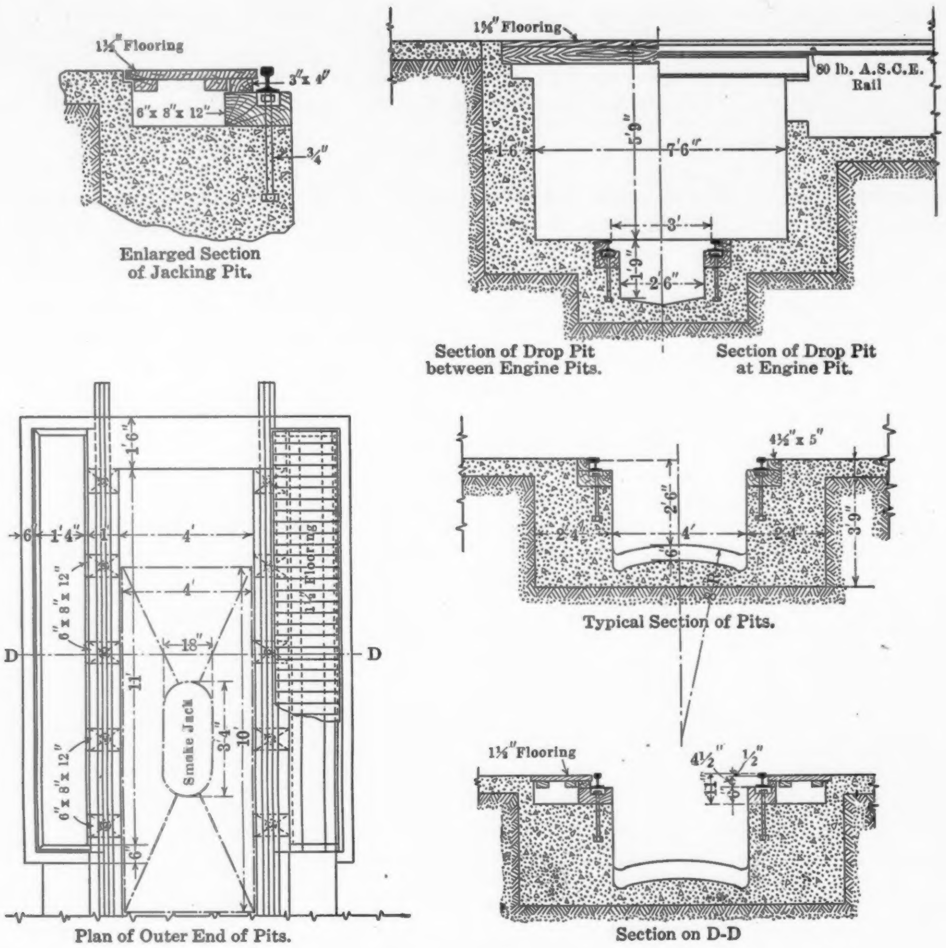


PLAN SHOWING RELATIVE LOCATION OF NEW ROUNDHOUSE AND ACCOMPANYING IMPROVEMENTS AT BLOOMINGTON, ILL.

An unusually liberal provision for drop pits has been made in this roundhouse, there being 12 pits served with driver drop pits and five other pits having a truck drop pit.

Over each alternate pit, located at about the center, there is a

36 by 24 in. cast iron roof ventilator, which is practically the only means of escape for the steam and gas, which always collects and hangs along the roof of a roundhouse. There is no opening around the smoke jacks or under the roof at the inner end, which is the highest point of the structure. The smoke jacks are of asbestos moulded to form and bolted together, the are of the customary concrete design under the floor, having branches running to each pit. There are also branches leading to outlets under the windows in the outer wall, discharging at a point 3 ft. 6 in. above the floor. The largest of the main heating ducts has a section of 47 by 60 in. at the fan and gradually reduces in size into 22 by 24 in. at the last stall, each duct serving

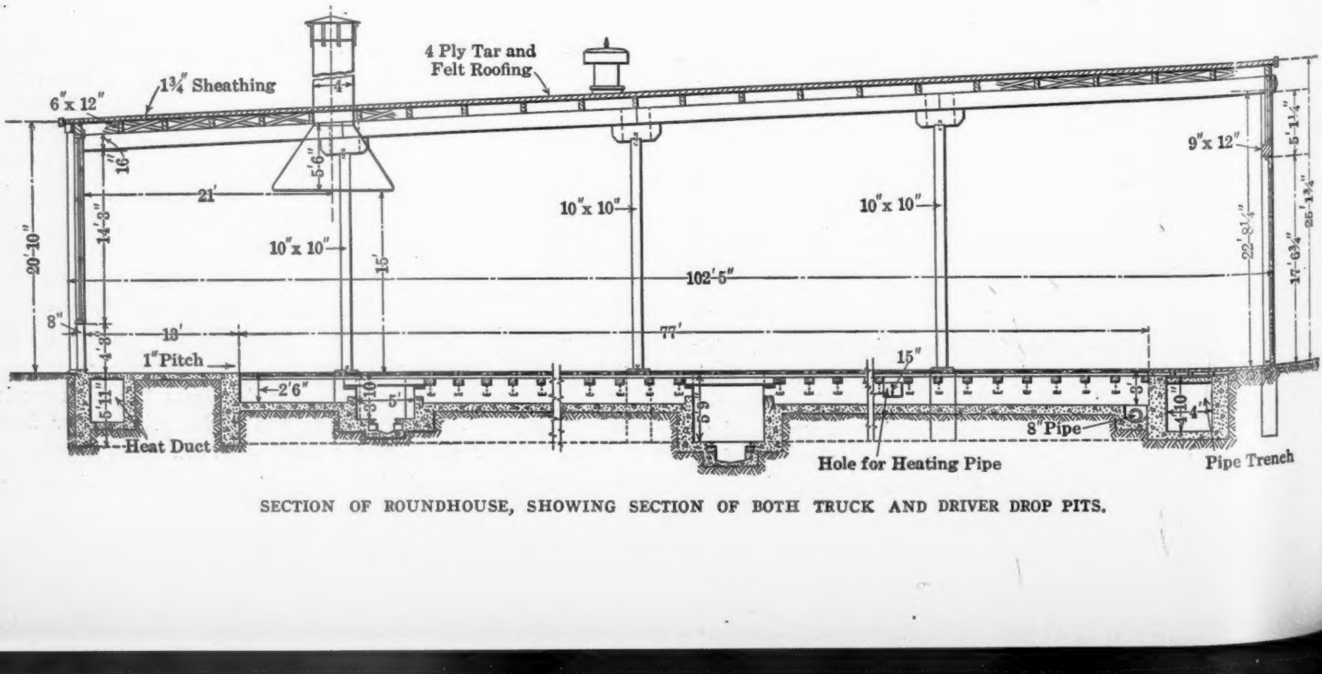


DETAILS OF PITS, SHOWING JACKING PIT AT OUTER END.

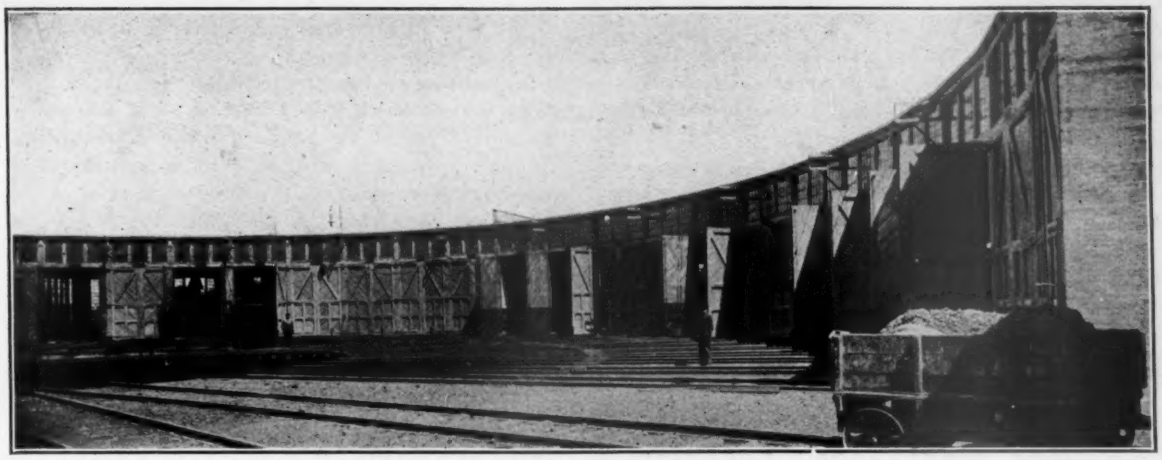
bottom of the hoods being 4 ft. in width and 10 ft. in length. They are carried to a good height above the roof, there being none of the straight section of the jack inside the house.

The heating is provided by the indirect system, using hot air supplied by two 180 in. engine driven fans, capable of completely renewing the air in the building in 18 minutes. These two fans are located in separate fan houses about 24 ft. square, built as small additions to the roundhouse. The heating ducts 15 stalls. Heat is supplied entirely by live steam from the power house, there being a 6 in. main carried to the roundhouse for running the fan engine, the pumps, steam blowers and for the steam heating coils.

One of the pits has been omitted and this space is occupied by the hot water boiler washing and filling system supplied by the National Boiler Washing Company of Chicago. (For full illustrated description of this apparatus see American Engineer,

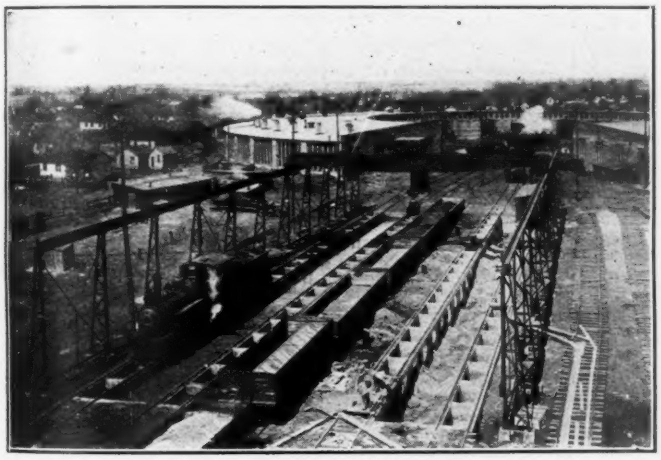


SECTION OF ROUNDHOUSE, SHOWING SECTION OF BOTH TRUCK AND DRIVER DROP PITS.



VIEW IN CIRCLE OF BLOOMINGTON ROUNDHOUSE.

Dec., 1910, page 469.) All piping from the boiler washing system, as well as the water, compressed air, etc., with the exception of the blowing off pipe, which is carried overhead, are installed in the pipe trench of concrete running around the circle at the inner ends of the pits. There is a separate fire line, con-



BIRD'S-EYE VIEW OF MECHANICAL CINDER PIT.

nected to the city water system, having sixteen two-inch plugs distributed throughout the roundhouse and vicinity. Artificial illumination is provided by 250-watt tungsten lamps, two of which are suspended from the roof over the spaces between stalls. For lighting the turntable and tracks outside there are four flaming arc lamps mounted on wall bracket fixtures on the inner circle of the house.

On the 100 ft. deck type turntable there is provided an electric turntable tractor furnished by George P. Nichols and Brother, which utilizes a 20 h.p. d.c. motor of the crane type. This apparatus also includes an electrically driven winch for handling dead locomotives.

On each of the four tracks leading to the roundhouse are provided cinder pits of large size, arrangement being made for mechanically handling the cinders. These four tracks are in pairs, between which there is a track located on the same level for cinder cars. Each pair of tracks are really served by one pit, the arrangement being such that the concrete bottom of the pits underneath the tracks slopes inward to a large open concrete pit between the tracks, the cinders being discharged entirely by gravity into this open space. The outer rail of each track is carried on the concrete retaining wall of the pits and the inner rail is supported on 18 in. I-beam stringers encased in concrete and resting on concrete piers 10 ft. apart, there being a reinforcing wall from each pier to the side of the pit, cutting up the length into 10 ft. compartments. Spanning both of the double pits and covering their full length there is a traveling crane, which operates a grab bucket and loads the cinders into the cars on the center track. This crane is of the four-motor type, operated from a cab carried on the trolley. The cinder pits are usually kept filled with water to a depth of 4 or 5 ft.

It will be readily apparent that this same cinder handling apparatus can be used in case of an emergency for coaling locomotives by simply putting the loaded coal cars on the cinder car track and using the grab bucket and crane to load the tenders. One of the illustrations shows the construction at this point very clearly.

A supply of coal can be obtained on any one of the four tracks that lead over the cinder pits, the station being of the elevated bunker type provided with crushers and bucket conveyors. The structure is of steel and reinforced concrete, entirely fireproof, and provided with coal handling apparatus in duplicate. There are two receiving tracks passing over a concrete pit about 35 ft. in length, in which are located two hoppers and crushers. Each crusher can discharge into

INTERIOR VIEW, SHOWING LARGE WINDOWS.

either of the two independent bucket elevators, each with a capacity of 80 tons per hour, and driven by a 15 h.p. motor. The crushers are operated by 25 h.p. motors. The coal handling part of the station was furnished by the Exter Machine Works.

In the coaling station is also provided a storage bin for dry sand, a supply of 7½ cu. yds. being stored for each of the four tracks. The sand is dried by steam dryers in a separate structure, and elevated by air pressure to the storage bin.

The general water service for the whole terminal is taken from the regular supply system at the shops, there being two new 100,000 gallon wooden storage tanks provided near the coaling station. These are located on a steel structure 20 ft. in height and from them water is distributed through 18 in. mains to the four 12 in. water cranes. A supply is also carried into the roundhouse for general service purposes.

In addition to the six inch line for the fans and general steam service there is a 3 in. line of steam piping carried to the sand dryer, an extension of which passes to the cinder pits for the purpose of thawing out engines in winter time. This line comprises about 1,000 ft. of underground pipe. Unusual precautions have been taken for protecting and draining this and the other steam lines, all of which are underground.

The whole terminal was designed and erected by Westinghouse, Church, Kerr & Co., New York.

Traveling Engineers Association, Nineteenth Annual Convention

A REVIEW OF THE VARIOUS COMMITTEE REPORTS AND THE DISCUSSION THEREON PRESENTED AT THE CONVENTION HELD IN CHICAGO, AUGUST 29—SEPTEMBER 1.

The nineteenth annual convention of the Traveling Engineers Association was held at the Hotel Sherman, Chicago, August 29 to September 1. F. C. Thayer, of the Southern Ry., Atlanta, Ga., presided, and in his address briefly reviewed the work of the association and called attention to the opportunities that are now presented the traveling engineers as individuals and as an organization for further effective work in promoting efficiency and economy. Mr. Thayer also directed attention to the importance of the traveling engineer in introducing proper tonnage ratings and securing proper locomotive maintenance. On the opening day Robert Quayle, general superintendent of motive power, Chicago and North Western Ry., in an excellent address made a strong personal appeal for absolute and fearless honesty on the part of the traveling engineers in the performance of their duties. In this latter connection Mr. Quayle said in part:

"The traveling engineer's duties are twofold—he must stand for the men, and he must stand for the company. Get the men with you and stand with them. They will pull for you, and thus for the company which you represent. Be honest! If you believe an engineman is not doing his best, ask him what is wrong with his fireman, and if he replies, 'Nothing,' ask him about his engine. He cannot blame it on the engine if you are on it and can see for yourself that it is all right. Then you can put it up to him. Tell him you can afford to give him $1,000 or $1,200 a year to stay at home and put some one else in his place. It will touch his pride, for he will not want to be classed below the average. It will make him think, and there will soon be something doing, for the truth pinches and squeezes hard.

"The traveling engineer should keep things stirred up, not alone with the enginemen, as suggested above, but with the roundhouse foreman, the master mechanic and the superintendent of motive power. If the roundhouse foreman allows work reported by the engineer to go out unattended to, it will make the engineer careless in reporting work. Ask the foreman why it was not attended to, and if he pleads the lack of help, ask him why he did not get more. Keep after and pound the master mechanic and superintendent of motive power for the assistance or co-operation which they should give. Do not report favorably on a device because your superiors are interested in it, financially or otherwise. They want to know the truth about it."

The number of carefully chosen and well presented committee reports forcibly attest to the value of the work being performed by this important association. The questions of fuel economy, efficient handling of the electric locomotive, developments and improvements in automatic stokers, Mallet compound engines in road service, lubrication of locomotives using superheater steam, and the benefits derived from the use of the brick arch were each ably presented and practically every paper was accorded an animated and valuable discussion. The practical nature of these subjects carries a particular appeal at this time, and it is very sure that much valuable data has been tabulated and a much better understanding of the various problems exists than prior to this convention.

The report of the secretary, W. O. Thompson, showed a membership of 812, an increase of 5.4 per cent. during the past year. He has a balance of $384 on hand, with no liabilities, and a considerable amount still due for membership dues, advertising and for examination books. The report of the treasurer, C. B. Conger, showed a balance on hand of $1,328.

PROPER INSTRUCTION ON FUEL ECONOMY

V. C. Randolph, supervisor of locomotive operation of the Erie Railroad, presented a valuable and timely paper on the subject, of which the following is an abstract:

It is not the intention to theorize as to what might or could be done, but to narrate what has been accomplished in actual practice on a railway, where on several divisions supervisors of locomotive operation were appointed who have charge of all locomotives in service, for the purpose of improving economies in the use of fuel, lubricating material, tools and other supplies. In the beginning it was thought advisable to first try it out on one division.

The accompanying chart shows graphically the saving that was made on freight and passenger locomotives of the Allegheny division during 1910 as compared to 1909; also the record for the first three months of 1911. The curves for the passenger locomotives are based on the pounds of coal used per locomotive mile, while those for freight service are on the basis of coal used per 1,000 ton miles. It will be noted that the savings during the first three months of 1911 were nearly as great as for the whole of 1910.

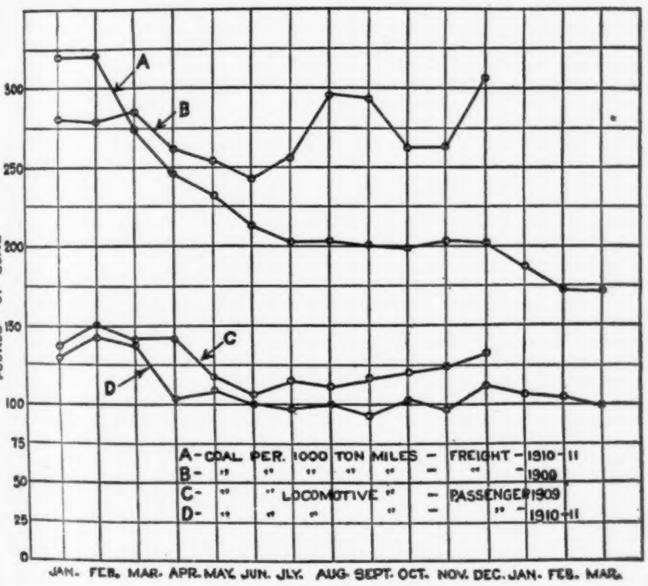
Mr. Randolph, through the presentation of tables, pointed to the saving which has been effected. It was shown that for the first three months of 1911, as compared with the same period of 1910, the total saving was $28,605.83. Another table illustrated that the total net saving—all classes of service—1910 as compared to 1909, amounted to $30,020.84. In these tables there was a slight apparent discrepancy between tons of fuel saved and its money value, but this is due to the fact that the price per ton was not uniform over the entire period under consideration.

The author of the paper described in some detail the various points of omission or commission which have a bearing on fuel economy. Many of these of course are elementary, and need not be repeated, but the value of the paper was not impaired by alluding to them. It was pointed out that personal supervision of the work of firemen has an important bearing on the general results, and that co-operation between the engineer, fireman and supervisor is no mean factor towards the end desired. In conclusion Mr. Randolph said:

The cleaning and keeping of fires at terminals is a very important question. A great saving in coal can be effected in cleaning fires by leaving them in proper condition and plenty of water in the boiler when they arrive on the ash-pit. This requires the co-operation of the engine crews and hostlers. The fire should be burned comparatively low, especially at the back end of the firebox, as about the first thing the cleaner does is to drop the

back dump grate. As a protection to the flues the fireman or hostler should, before leaving the engine on the arriving track, throw a few shovelfuls of coal into the forward end of the firebox. In cleaning the fire, any unburned coal or live fire in the back end should be pushed ahead, the back section of grates shaken, then the dump grate dropped (when the dump is next to door sheet), and any clinkers broken up and disposed of. The forward section of the grates should then be shaken and any clinkers pulled back and forced through the dump. After this operation the grates should be leveled and the dump grate closed. If the engine is to lay over several hours, the fire should be pushed ahead, leaving the dump and one or two grates bare, then covered over as the condition of the fire warrants, in all cases sufficiently to prevent the pops opening. When the engine is ordered, the fire should not be broken up until shortly before leaving time, unless necessary on account of poor fire. The excessive use of the blower should be guarded against at all times and especially when cleaning the fire. The roundhouse foreman and staff should understand the importance of keeping the draft appliances, grates and flues in proper condition.

The condition of the locomotives is the governing factor in effecting fuel economy, and it would be poor policy to neglect repairs that would cost a few dollars and by so doing consume perhaps a hundred dollars' worth of coal per month or even more. The location of the steam gage should be given more attention, particularly on the large locomotives, as close firing requires close observation of the pressure. If a swing door, the latch should hold it positively open when putting in coal; when practical, a small chain should be provided, hung from some convenient point and only slack enough to allow it to drop into place. The deck sheet should be closely fitted, leaving no holes for coal to drop through. By looking after these apparently small points it helps to get and keep the co-operation of the engineer and



COAL RECORD ON ALLEGHENY DIVISION OF THE ERIE, 1909-10-11.

fireman, and in this way a greater reduction in fuel may be made than by any device which can be applied to a locomotive.

The benefits derived by educating firemen in the art of handling fuel and the savings effected thereby have resulted in issuing a book called "Good Firing," which is given to each fireman when entering the service; a book of elementary questions also is furnished at the same time. At the expiration of his first year's service he is required to pass a written examination, which is verified by an oral one conducted by the road foreman of engines or other persons appointed by the proper authority, necessary knowledge being obtained from the book furnished, attendance at instruction classes held by the road foreman or supervisor of locomotive operation; also from information received and instructions given him by either, when on the engine or otherwise.

At the end of the first year and after passing the examination, the first year's question book is returned and the list of questions on the second series is given him. At the expiration of the second year, another examination follows, which is progressive in form, it being a little harder to obtain the answers. The third year's series consists of his final mechanical examination, which, if satisfactorly passed, qualfies him as a locomotive engineer.

To create interest in a competitive way among all engineers, an individual performance sheet is issued monthly on each division, which shows the name of each engineer, the number of his engine (when regularly assigned), the engine mileage made by each engineer, the amount of lubricating material used and cost per 1,000 locomotive miles, also the miles made per pint of oil. It also shows the number tons of coal used and cost per 1,000 ton miles in freight service, and the number tons of coal used and cost per 1,000 locomotive miles in freight, switching and passenger service, respectively. In freight service the total ton-miles moved are also shown. The cost of tools and other supplies is shown on the 1,000 locomotive mile basis for all classes of service. A percentage column relates entirely to each of the three sub-divisions, the percentage being based on the lowest performance, i. e., the lowest in cost will be classed as 100 per cent., all others being of a corresponding ratio. While costing considerable time and money to prepare a report of this kind, it has proved itself to be a good investment to the company, for as a rule each engineer and fireman takes pride in trying to reach the 100 per cent. mark.

Discussion: The general interest in this subject naturally resulted in a thorough discussion which developed many features of value. One significant point brought out was that the enginemen cannot be expected to make great efforts to save fuel by the scoopfull if they see it wasted in innumerable ways before it gets on the tender, therefore the importance of fuel saving should be appreciated by the entire organization from the top down.

On the high capacity locomotives where the fireman is forced to work near his limit, the problem of closing the fire door after each shovelfull becomes a serious one. Several of the members spoke very favorably of the use of automatic fire doors under these circumstances. An instance was also cited where the heat prostrations during the summer months were greatly reduced, due to the application of such doors. The company should do its part in making the work of the men easier. Undoubtedly the engineer would just as soon hook the lever up a little higher, if he was sure that it would not interfere with the lubrication of the valves and cylinders, and if the lever could be easily handled, so as not to threaten to jerk him off the seat box.

One speaker said that the first place to begin fuel economy was in improving the condition of the engines. He also experiences a great deal of trouble in securing firemen and believes that the only solution of the problem is in the introduction of mechanical stokers. The best results in obtaining fuel economy are only possible with the hearty co-operation of the higher officials; the road foreman must have their backing to enforce his orders.

Mr. Randolph said in reply to a question that in riding the engines he checked the work of the fireman carefully. By means of a counter in his pocket he kept track of the number of shovelsfull fired. Of course the different firemen vary as to the amount they carry on the shovel, but by watching closely this could be estimated with a fair degree of accuracy. The figures at the end of the run were checked against the amount of coal remaining on the tender. In this way it is possible to get a good line on the men, especially when a number of records have been taken for different men on the same run and under similar conditions.

Where a man's record is poor, as shown by the monthly performance sheets, the matter is taken up with him privately; letters are used only under extreme conditions. The transportation department has assisted in the work where matters have been called to its attention which could easily be remedied. On the Allegheny division of the road the coaling stations are such that a fairly accurate estimate of the coal given to each engine is possible.

MALLET COMPOUNDS IN ROAD SERVICE

J. B. Daugherty (B. & O.) presented a very complete paper on this timely subject, one which probably may be regarded as one of the most important of those read before the convention. Locomotives of this type have been considered by many as best adapted for pusher service, therefore this data illustrating their usefulness in actual road work is of considerable value. The salient points of the paper are as follows:

The Baltimore & Ohio Mallet locomotive No. 2400 was put into regular helper service on the Connellsville division. From January 6, 1905, to and including September, 1909, the locomo-

tive made 113,956 miles, the major portion of which was in helping service between Rockwood and Sand Patch. During this period it received classified repairs as follows: Class 4, F. T., Connellsville, February 15, 1906; class 3, Connellsville, June 7, 1907; class 4, F. T., Connellsville, June 11, 1908. Shortly after September 30, 1909, it was shopped at the Riverside shop for class 3 repairs. During the period referred to above the locomotive was available for transportation use 33,499 hours, and unavailable 6,405 hours, or it was available for transportation use 84 per cent. of the time. The cost per 100 miles run for repairs, including running and classified, averaged $9.04. The cost of operating this locomotive from the time it was put into service up to and including September 30, 1909, including repairs, fuel, supplies and in fact every item of expense entering into the operation and maintenance of the locomotive per 100 miles run, amounted to $46.96, based on the actual mileage made by the locomotive during this period.

On February 20, 1906, it was used in road service with a view of making a test against two Class E-27 locomotives, with the same tonnage as handled by locomotive 2400. The results of the test were as follows:

	Two E-27	No. 2400
Number of cars	38	35
Tons	2,473	2,435
Actual running time	2 hrs. 45 min.	**3 hrs. 43 min.**
Coal consumed	30,000 lbs.	**20,000 lbs.**
Pounds of coal per locomotive mile	698	**465**
Pounds of coal per car mile	18,334	**13,280**
Pounds of coal per ton mile	.282	**.191**
Water consumed	19,200	**15,700**
Water evaporated per pound of coal	8 lbs.	**6.05 lbs.**

Locomotive 2400 used 25 per cent. more coal than one of the Class E-27 locomotives and 33⅓ per cent. less fuel than two E-27 locomotives. The lubrication of the Mallet locomotive compared with other locomotives in the same service for twelve hours was: locomotive 2400, three pints valve oil, five pints car oil, one-half cup grease; cost, 32 cents; two E-27 locomotives, three pints valve oil, three pints car oil, one-fourth cup grease; cost, 27 cents.

We have experienced no trouble keeping firemen on locomotive 2400, as they are paid 25 cents per day more on this engine than on consolidation engines in the same service. Locomotive 2400 decreases rail and tie strain since it has but 11 ft. rigid wheel base, and can be handled over track where the heavy consolidation locomotives cannot be used. We have experienced no difficulty in keeping the flexible joints tight in the low pressure steam and exhaust pipe joints.

The consumption of fuel by the Mallet compound locomotive equipped with a superheater on the Chesapeake and Ohio Ry. is about one ton of coal less per trip than for an ordinary consolidation locomotive. The Mallet locomotive not equipped with a superheater consumed about one ton of fuel more than the consolidation locomotive. The average cost of lubrication on the Mallet, as compared with all other classes of locomotives, is about 50 per cent. greater on account of the large wearing surfaces. The average speed of the Mallet is about the same as that of consolidation locomotives; they are able to attain a speed of forty-five miles per hour. Firemen consider it less exertion to fire a Mallet locomotive than other classes of locomotives. Judging by the work that has been performed by Mallet locomotive 751, it will make the same mileage and handle 50 per cent. more tonnage than the consolidation locomotive between classified repairs.

Tests were made on the Great Northern, where Mallet locomotives are in regular through freight service, between Minot and Williston, N. Dak. The division is 122 miles between terminals. Going west from Minot there is a grade of .72 per cent. for a distance of thirteen miles, then a lighter grade of .5 per cent. for a distance of eight miles. The road from that point for a distance of seventy-five miles is what might be termed a rolling prairie with gradual ascending and descending grades; the last eighteen miles of the division have an ascending grade of .72 per cent. into Williston. The Mallets have 20 in. & 31 in. x 30 in. cylinders, 55 in. driving wheels, carry 210 lbs. steam pressure and are of the 2-6-6-2 type. During the summer months these locomotives are rated at 2,200 tons over this division.

The heaviest tonnage handled by the Mallet locomotive during the time of these tests was 1,615 tons in forty-four cars. With this tonnage it consumed one hour and thirty minutes in covering the first thirteen miles of .72 per cent. grade. From that point the grade is somewhat lighter, and the train arrived at Berthold, twenty-two and a half miles from Minot, in two hours and twenty minutes. From this point, as previously stated, the road is a gradual rolling prairie and the next twenty-four miles were covered in one hour and thirty minutes, arriving at Williston in eleven hours and twenty minutes from the time the train departed from Minot, including delays by meeting trains and taking water and coal. The Mallet handled this tonnage over heavy grades with considerable less shock to draft rigging than the consolidation locomotive, because both units of the Mallet never slip at the same time and the slack of the train does not run up as in the case of a consolidation locomotive when slipping on a heavy grade. For this reason the Mallet is considered more reliable to handle tonnage over hard pulls than a consolidation locomotive. The speed of the Mallet will be materially reduced as soon as it strikes a slightly ascending grade, while the consolidation locomotive will go over the same grade at quite a high rate of speed. For this reason the consolidation locomotive will make considerably better time on a road which has broken grades. I am unable to give an accurate report as to the amount of coal consumed by the Mallet as compared with the consolidation, but from what I was able to observe while riding these engines I have come to the conclusion that the Mallet type will burn a little more coal per engine mile than the consolidation, but figuring on a 1,000-mile basis, the Mallet will show considerable saving. The Mallet uses about again as much lubrication as the consolidation.

Discussion: It was developed that where opposition had formerly existed to the employment of the Mallet in regular road service, it had become largely removed after personal observation of these engines under such conditions. Mr. Roesch, for instance, spent 30 days on the division of the Santa Fe where Mallet's are on through runs. He had been badly prejudiced against them, but was thoroughly converted.

In one instance he was on a Mallet pulling 60 loads with a tonnage of 2,300. It went over the division of 102 miles, and as no locomotive was available was forced to go right on over the next division of 98 miles, and then the next one of 108 miles. In all 308 miles were covered in less than 15 hours, all delays included. The average speed of these locomotives over a division with .6 per cent. grades is from 25 to 29 m. p. h., although much higher speeds are attained—as high as 45 miles per hour. Every convenience is provided for the enginemen, including air operated fire doors, bell ringers, reverse levers and cylinder cocks; also coal passers. No trouble is experienced with break-in-twos and the trains get under headway quickly.

W. F. Walsh (C. & O.) was enthusiastic over the results being obtained from the Mallets in road service. They are handling all classes of freight and are of the 2-6-6-2 type with 56-in. drivers and 22 in. & 35 in. x 32 in. cylinders. They are economical both in fuel and maintenance as compared to the consolidation locomotives. A train of 2,061 tons was hauled over a 77 mile division in 3 hr. 8 min. The first 32 miles had a rise of 22 ft. to the mile; the next 17 miles, 30 ft to the mile; the next 17 miles a down grade of 60 ft. to the mile, and the remaining 11 miles were rolling.

The consensus of opinion seemed to be that Mallet locomotives, specially designed to meet varying requirements, could be used to splendid advantage in road service. It was suggested that any new type of locomotive is expensive to maintain until the men become familiar with taking care of its various details, and that this particular objection could be very easily disposed of seemed to be in the main agreed upon by all who discussed the paper. The question as thus presented before the convention is necessarily one which must command the attention of all motive power chiefs in the very near future. If this type can operate successfully on long runs, and on such runs demonstrate the same efficiency which it has exhibited in the rather constructed field where largely heretofore employed, a great problem will have been solved. This solution largely implies the abolition of the double-header in freight service, and a greater tonnage moved at a much lower ratio of general costs. For these reasons it is believed that this particular paper is of more than passing value, not only to the convention before which it was presented, but to those who must decide in regard to the type of power to be employed for the movement of the heaviest tonnage at the minimum cost.

THE BRICK ARCH

That this is a subject of great interest cannot be denied. The proper maintenance of this appliance, in the instance of a road owning say 1,000 locomotives, means no less than $30,000 per year. This in itself may not appear as an excessive item in locomotive maintenance, provided that the item is really justified. There is, however, considerable difference of opinion about the arch. By many roads it is received as a luxury, pure and simple, because the argument cannot be denied that the locomotive's steam as well without as they do with it. In the abstract, how-

ever, many other reasons may be advanced for its use, which were set forth by the committee, Messrs. Tawse, Cooper, Butler, Wright and Randolph, in part as follows:

The design and construction of the brick arch to-day is the result of several years of close study, painstaking investigations and experiments by men of large experience in locomotive operation, resulting in eliminating the objections that have heretofore existed against the brick arch. The most noticeable improvement in brick arch construction is the sectional arch, the brick being made of small units, so that certain sections can be removed for flue work and staybolt inspection, without interfering with the other portions of the arch, resulting in the saving of the arch and of time due to installing a new arch.

Other things being equal, the brick arch adds to the boiler capacity by making each square foot of heating surface count for more steam. This because of the fact that the firebox temperatures are always found to be increased by the installation of the brick arch. The brick arch adds to the firebox capacity and the fireman's capacity, because the more complete combustion forces each pound of coal to yield a higher percentage of its total heat units. It saves coal because of the better combustion and because of the baffling and retaining effect on the gases and on the fine and light combustible matter, which otherwise would be drawn through the flues in the form of sparks or partly consumed coal.

The brick arch abates the smoke and cinder nuisance by more thorough combustion, due (1) to the better mixing effect of the gases and oxygen of the air drawn into the furnace chamber, and (2) that the longer flame travel gives more time for combustion to be completed before the gases pass into the tubes and are lost. The baffling effect on the cinders is a thing that can be determined, and numerous tests carefully conducted show a very marked decrease in cinder throwing due to it.

The brick arch affords a protection to the flues. This statement can be verified by inquiring of almost any one responsible for the up-keep of flues who has had opportunity to observe the difference in this respect between arch engines and no-arch engines. The result is due, no doubt, to the fact that wide and sudden variations in flue temperatures are prevented by the presence of the arch.

The reasons for a growing demand for brick arches are many, the principal ones being:

1. The growing demand for boiler capacity and fuel economy. This was met in years gone by with larger designs. There was plenty of room for growth in size and weight of boiler and plenty of margin in fireman capacity or endurance. Not so now. These limits are reached, hence the requirements such as brick arches, superheaters and other devices to further extend the capacity of the boiler.

2. The growing public sentiment and demand for economy in railway operation. The consumers of transportation are putting forth arguments for properly enforced methods of economy, hence any accessory that will yield a net saving of even 5 per cent. of a railway fuel bill cannot longer be ignored. A brick arch will give a net saving of from 5 to 15 per cent., depending upon the conditions of operation.

3. The growing public sentiment against the smoke and cinder nuisance. The time is drawing near when the public will demand either the suppression of the smoke and cinder nuisance, or the suppression of the steam locomotives. The arch is recognized as one of the best smoke preventers and as one of the most efficient devices for reducing the quantity of sparks thrown from the stack, and on this account it becomes directly valuable as a fuel saver.

From the replies received it is quite evident that the nozzle tips can be opened up with the application of the brick arch. This is accounted for by a greater percentage of the gases from the coal being consumed; as the function of the brick arch is that of a mixer it brings about a more complete mingling of the gases, thereby aiding combustion, resulting in higher temperatures in the firebox. These claims have been fully sustained by many experiments made on different roads. Many of the replies are very flattering on the benefits derived from the use of the brick arch where water conditions are considered bad, the steam failures having been reduced from 50 to 75 per cent. Instances have been cited where locomotives arrived at terminals with flues leaking each trip without the arch (all are familiar with the excessive loss of fuel with leaking flues) and since the arch has been applied the same locomotives are now making several trips before flues need attention. These favorable results are due to the uniform degree of heat maintained in the firbox, and elimination of the cold air passing through the firebox door, being deflected by striking the arch before reaching the flues.

We do believe that theoretically there should be no opening next to the flue sheet and that all the gases should be made to pass over the rear of the arch. In actual practice, however, there are localities in which conditions are such as to require clearance at the front, and our only recommendation in this regard would be to experiment with the arch tight to the flue sheet, bringing the drafting of the smoke box to favor it as much as possible, and if, after a thorough trial has been made, success is not met with, use a small spacer block on the tubes. A compromise may be effected by having the middle section tight to the sheet to protect the lower central flues, and the side courses set back to give clearance through which accumulations may be discharged to the grate. This is a question which will no doubt bring out some good discussion on the results of the location of the arch.

A test was recently made on the New York Central Lines with a wide firebox type of boiler to ascertain the efficiency of the brich arch and arch tubes. The boiler was equipped with four water bars 3 in. in diameter; 458 tubes, 15 ft. 6 in. x 2 in.; firebox length, 105 in.; width, 75¼ in.; steam pressure, 200 lbs. The evaporative power of the boiler is increased 14.9 per cent. by using the brick arch in the firebox. One-third of this increase is accredited to the water bars, while the remaining two-thirds must be due to the brick arch itself. The reason for this increase is perhaps the storage of heat in the brick arch at an advantageous place near the back flue sheet; the forcing of the path of the flame upward to the crown sheet and on through the upper flues, which are the best heating surfaces of the boiler, and keeping the flues clear of fuel. Without the brick arch, fuel is often thrown or carried by the draft into the lower flues, plugging them and thereby rendering these flues useless. It is very noticeable that there is a saving to the flues caused by the brick arch; for when the firebox doors are opened the in-rushing air must first come in contact with the hot arch and thereby become heated before reaching the flue sheet.

LUBRICATION OF LOCOMOTIVES USING SUPERHEATED SYSTEM

The committee appointed to consider and report upon this important subject consisted of M. H. Haig (Santa Fe), chairman; W. R. Taylor (Gal. Sig. Oil), F. W. Edwards (Ohio Inj.), A. Maynes (Can. Pac.), and S. Beidelman (C. R. I. & P.). In part the paper was presented as follows:

The effect of superheat upon lubrication depends on the temperature of the superheated steam. The smoke-box type provides for superheating from 30 to 80 or 90 deg. Fahr. above the temperature of the saturated steam, while smoke-tube superheaters have in some cases produced over 300 deg. Fahr. of superheat. Conditions attending the use of low and high superheat will be considered separately.

Steam temperatures reported to the committee by the roads using smoke-box superheaters do not exceed 490 deg. Fahr. At the temperature obtained with smoke-box superheaters little trouble has been experienced from the use of the same methods of lubrication as employed on saturated steam locomotives and practically no changes have been made. Oil is being delivered to the center of the steam chest for slide valves and inside admission piston valves. Where outside admission piston valves are used the oil is introduced into the ends of the valve chamber. In some cases the cylinders have been tapped to receive direct lubrication at a point in the middle of the bore and near the top. Experience with this method, however, in some instances has led to the belief that as good results would be obtained by the usual method of feeding all the oil to the steam chest. All roads report having found it unnecessary to change the quality of oil with the application of low degree superheat. The oil in use has a flash point of about 520 deg. Fahr. There has been but little increase in oil allowance attributable to low superheat. Very little data has been received showing the effect of low degree superheat on the wear of valve and cylinder packing rings. No case has been brought to the attention of the committee where any change of material from that used with saturated steam has been found necessary. In some cases the wear appears to be a little more rapid. No change in the material of the rod packing has been made.

Eight roads have reported the use of smoke-tube superheaters, the superheat obtained varying from 100 to 200 deg. Fahr., with corresponding steam temperatures of 490 to 580 deg. Fahr. Other than increasing the quantity of oil used with either saturated or superheated steam, high boiler pressure has no effect upon lubrication.

There are several methods of introducing oil to the valves and cylinders. Two roads consider it necessary to introduce part of the oil directly into the cylinders. Others with engines so equipped have found it unnecessary to use the cylinder feed continuously, but retain it as a precaution against cutting cylinders in emergency. This is deemed desirable, as oil will reach the piston rings with less delay than when introduced through the valve chamber, especially when the engine is drifting. In providing for direct lubrication of the cylinders, it is the practice of the roads reporting to introduce oil in the middle of the piston travel and as near to the top center line of the cylinder as the construction will permit.

Satisfactory results are obtained by the use of the following methods of feeding oil to the steam chest. They all apply to inside admission piston valves. (a) Two feeds per steam chest,

one delivering oil near each admission port, preferably a little toward the center of steam chest from the ports. This is effected in two ways: by a lubricator feed for each point of delivery, or by two lubricator feeds and oil pipes branched near the steam chests. (b) The customary one feed per steam chest, introducing the oil into the center of steam chamber. (c) One feed per steam chest, introducing oil into the steam channel at a point near the steam chest. (d) Three feeds per steam chest, one in the center of the steam chamber and one at each end near the admission ports. Each point of delivery has an individual lubricator feed. The road using this method makes no provision for direct lubrication of the cylinders. The use of graphite is reported by one road. In addition to valve chamber and cylinder oil pipes, Campbell graphite cups are piped to the relief valves of a number of engines.

To insure proper lubrication at all times, it is recommended by some that steam be admitted to the cylinders when drifting. It has been found that even though proper lubrication is obtained while working steam, the valves and cylinder walls become dry after drifting for some time. A drifting valve will let sufficient steam into the valve chambers and cylinders, if properly handled by the engineer. It is reported that by proper care on the part of the engineer in always opening the drifting valve before closing the throttle it is possible to obtain a material increase in life of packing rings. One road connects the drifting valve to the superheater, passing the steam through the superheater before delivering it to the cylinders and reports very satisfactory results. Several roads have made use of mechanical feed lubricators with superheated steam, but it has not proved as satisfactory as the hydrostatic type and its use has been abandoned for the latter.

D. R. McBain, superintendent of motive power, Lake Shore & Michigan Southern, has devised and patented a means of insuring uniform delivery of oil to the steam chest of engines using superheated steam. It is used in connection with the hydrostatic lubricator. Dry steam is led from the boiler through a 1¼-in. pipe to a valve which is so arranged as to be opened by the throttle lever. When open, steam passes through two ⅜-in. copper pipes directly into the steam chest oil pipes, just ahead of the choke plugs at the lubricator end of the pipes. The steam-chest choke plugs are drilled out to the full size of the oil pipes, ⅜ in. in diameter. By this means there is a constant flow of steam through the oil pipes to the steam chest, insuring a constant and uniform delivery of the oil.

Several grades of valve oil are used on locomotives equipped with high degree superheaters. Flash points of 550 to 600 deg. Fahr. have been reported, but in most cases the same quality is provided for superheated steam locomotives that is now used with saturated steam.

High superheat has increased the quantity of oil used on valves and cylinders. The amount of this increase varies in different cases from 10 and 20 to 100 per cent. The larger percentages reported are due to the delivery of oil directly to the cylinders without a reduction in the quantity fed to the steam chest. In these cases the question of minimum oil consumption has not been extensively considered. The purpose has been to use a liberal amount of oil rather than to risk trouble from insufficient lubrication. The following statement was made by one who has had wide experience with highly superheated steam: "We are running about the same mileage on superheated steam engines as on saturated steam for valve oil, but I consider that the superheated steam engine should be given 10 to 20 per cent. more oil than the saturated.

The wear of cylinder packing rings is increased by the use of highly superheated steam. Introducing oil directly into the cylinders has not overcome this condition. The use of special material for packing rings has been attended with good results. The difference in wear of valve packing rings and valve chambers bushings is less noticeable. Piston rod packing has been very little affected by the use of superheated steam.

A few precautions should be observed in connection with the installing and operation of hydrostatic lubricators. Oil pipes from the lubricator to the valve chambers should be absolutely steam tight to insure the delivery of oil to the proper place. Care should be taken that the lubricator pipes slope toward the cylinders on an even incline throughout their entire length. To prevent the pipes being distorted they should be protected by placing them under the boiler jacket. The steam pipe from the boiler to the lubricator should be of ample size to insure full boiler pressure at the lubricator. It is desirable to start the lubricator from fifteen to twenty minutes before leaving time. It is reasonably certain where this is done that the valves and cylinders will be receiving oil when the engine is started.

All information on lubrication of locomotives received from various sources agrees so closely on the principal points, that the committee feels justified in the following conclusions:

1. The conditions affecting lubrication are practically unchanged by the degree of superheat commonly obtained from smoke-box superheaters.

2. The flash point of valve oil should be higher than the temperature to which it will be subjected at the point where lubrication is to be effected. Oils now available fulfil this condition, and if delivered to the proper surfaces will lubricate satisfactorily.

3. The hydrostatic lubricator meets the requirements of proper oil delivery. It is considered more satisfactory than the mechanical feed lubricator because of absence of moving parts to wear and get out of order.

4. The life of common gray iron packing rings is too short to commend this material for use with high degree superheat.

Discussion: There seemed to be a more or less well defined opinion in the minds of some of the speakers that entirely too much oil is being used on superheater engines. The men in charge are not yet thoroughly acquainted with the performance of these engines and are afraid to take too many chances with them. As they become more familiar with them they will find it possible to get just as good results with much less oil than many are using at present. There seemed also to be a feeling that the oil pipe direct to the cylinder could be dispensed with. The tallow pipe connected directly to the steam passage in the cylinder saddle was very favorably spoken of.

Incidents were cited where a change in the material of the cylinder packing rings produced good results. The Pittsburgh & Lake Erie has a high degree superheater with slide valves. D. J. Redding, assistant superintendent of motive power, believed that the lubrication difficulties were due to sudden shutting off the steam; he had found evidences of the oil being burnt when the engine came into the terminal station. He suggested an auxiliary steam line to the cylinders so that a small amount of steam could be introduced in the cylinders after the throttle had been closed, or else the application of larger relief valves. The discussion developed the fact that it is advisable to use a drifting valve when drifting, this valve being opened before the throttle is closed. It allows a small supply of steam to enter the cylinders through auxiliary pipes. The packing troubles can usually be traced to drifting or suddenly shutting off at high speed. Not much trouble, for instance, is experienced with low speed superheater freight engines.

It was stated that the Union Pacific had a superheater engine with slide valves, and that successful results were being gained by the use of bronze valves and valve seats. The C. & O. has 24 superheater Mallets which are used in through fast freight service. The oil is introduced directly into the steam pipe and also directly to the low pressure receiver. Schmidt superheaters are used and Galena superheater oil. The packing has not given any trouble. These engines have no drifting valves and drift down a 17 mile 1.3 per cent. grade at a speed limit of 20 miles per hour.

DEVELOPMENTS IN AUTOMATIC STOKERS

An extensive report on the subject was presented by J. R. Luckey, in which was discussed the Crawford, Hanna and Street stokers and the performance of each commented upon. It was advanced by its author that these three stokers are "making good" and he did not allude to those of other design which are in limited use. While of interest, the paper did not awaken an extensive discussion, which was probably due to the fact that the same subject was given considerable attention during the last Master Mechanics' Association Convention, and whatever new was to be said became apparent at that time. Experiments as yet are still confined to a narrow scope, but the building of a few more stokers of the same kind for each road is a healthy indication, and the extension to a wider field appears to be but a question of time.

CONVENTION BUSINESS

The committee on subjects suggested eleven subjects for 1912. These were referred to the executivee committee with the recommendation that a selection be made from them and that fewer reports be arranged for next year. In almost every case this year the discussions had to be "choked off," in order to get through the work of the convention in four days.

C. F. Richardson, the retiring president in 1910, was unable to represent the association at the Master Mechanics' convention

at Atlantic City last June, and W. C. Hayes (Erie) was delegated to do so. He presented a detailed report of the proceedings, emphasizing those features which are of special interest to the traveling engineers.

The southern members made a strong plea for the 1912 meeting. As a result Atlanta, Ga., received 71 votes, Chicago 53, and Washington, D. C., 10. There seemed to be a strong feeling on the part of many that Chicago being more central and having had the most successful meeting in the history of the association, should be again selected. The executive committee will select one of the three cities, Atlanta being given the preference if conditions will warrant.

The fiscal year will close August 1 instead of August 15. An associate member of one year's standing can make application for active membership. The president must be selected from a man in active railway service and holding the position of road foreman of engines, or a position ranking above it. The secretary can pass on the applications for associate membership.

The Traveling Engineer's Supplymen's Association elected the following officers: President, J. Will Johnson, Pyle National Headlight Company, Chicago; secretary, W. L. Allison, Franklin Railway Supply Company, Chicago; treasurer, Frank D. Fenn, Crane Company, Chicago; executive committee, W. J. Schlacks, McCord & Company, Chicago; Frank H. Clark, the Watson-Stillman Company, New York; P. H. Stack, Galena Signal Oil Company, St. Paul, Minn.

ELECTION OF OFFICERS

The following officers were elected for the ensuing year:

President, W. C. Hayes, Erie R. R.

First vice-president, W. H. Corbett, Michigan Central.

Second vice-president, F. P. Roesch, El Paso & Southwestern.

Third vice-president, John McManamy, Pere Marquette.

Secretary, W. O. Thompson, New York Central.

Treasurer, C. B. Conger, of Wm. Sellers & Co.

Executive Committee members, J. C. Petty (N. Y. C. & St. L.), F. C. Thayer (Southern), and V. C. Randolph (Erie).

The Efficiency of Milling Cutters

A RECOMMENDATION TO INCREASE THEIR TOOTH SPACE AND DEPTH WHICH HAS MANY APPEALING FEATURES, AND WILL NO DOUBT FURTHER ENHANCE THE VALUE OF THIS IMPORTANT MACHINE TOOL.

The rapidly extending use of the milling machine, and particularly the inroad which it has made into the field heretofore exclusively occupied by the planer, has awakened a general interest in a tool which formerly was far from being considered as one of a wide range of efficiency. From the position it once occupied in the railroad shop, as what might be termed a luxury, it has come to be regarded as a practically indispensable adjunct, and the progress of its development is probably being accorded more attention than is given to any other machine tool at the present time.

It is very interesting in this connection to note that while the prevailing design of bed, drive and the essential features are such that little further improvement can be reasonably looked for, there still remains an extensive field for experiment and ingenuity in the development of the cutters. This subject is now being given very careful consideration in many quarters and several elaborate tests are under way in shops of the machine tool builders with the end in view to determine what course shall be followed to increase the efficiency of the cutters.

The milling of metallic surfaces of course requires a rotating cutter provided with one or more teeth having an edge and temper suited to the nature of the material operated upon. Great hardness of the material to be cut, or a dull tool, will severely strain the machine and so reduce the section of the chip, even if the machine is rigidly constructed and well supplied with driving power. It is therefore of the greatest importance to analyze carefully all the conditions which cause heavy strains so that they may be obviated or reduced to the lowest possible limit.

These considerations were fully discussed in an extremely valuable paper by A. L. DeLeeuw which was recently presented before the American Society of Mechanical Engineers. It was pointed out that observations of present day practice and a number of experiments indicate conclusively that better results can be had from milling cutters by increasing the tooth space and depth. A number of cutters constructed along these lines were tested and it was found that they have a number of points in their favor, among which are a less consumption of power, a greater amount of work done for one sharpening and a greater number of possible sharpenings per cutter. A change in the form of chip breaker made it possible to use cutters with chip breakers for finishing, as well as for roughing. This very important addition to existing literature on milling cutters ended with a description of a new style face mill, and what is called a helical mill.

In general, attention is called to the possibilities which lie in a more scentific construction of milling centers and the desirability of discarding ideas which are largely based on conditions no longer existing. In part the paper may be quoted as follows:

Limitation of the cutting capacity occurs in all metal cutting machines, although to a varying extent. While it is possible to increase the driving power of most machines *ad libitum*, and almost any amount of metal can be put into machine elements to give them rigidity, there are certain classes of machines where practical considerations limit such increase of power and strength. This is especially true in machines where the main elements have to be adjusted and handled with great frequency. The knee-and-column type of milling machine owes its success, to a large extent, to the ease and rapidity with which it can be manipulated, and it is doubtful if it will ever be possible to increase the dimensions of the parts much beyond the present sizes, without losing the benefits of the peculiar construction of this type of machine. In order to increase the capacity of this type of milling machine, it becomes necessary to reduce the strains set up by the cut and there are only two elements which can be modified to accomplish this result. These are the hardness of the metal to be cut and the cutting qualities of the milling cutter. As it is impossible to control the first of these, the only avenue left for improvement leads in the direction of the milling cutter.

The author of the paper then commented at some length on the form of cutters, and in his recommendation that the tooth space should be increased had the following to say, which is of considerable interest:

It is a common belief that better finish can be obtained with teeth closely spaced, but experience with the wide-spaced cutter shows that there is no ground for this belief. The grade of finish may be expressed by the distance between successive marks on the work. These marks are revolution marks and not tooth marks. It is practically impossible to avoid these revolution marks. They are caused by the cutter not being exactly round or quite concentric with the hole, by the hole not being of exactly the same size as the arbor, by the arbor not being round, by the straight part of the arbor not being concentric with the taper shank, by the taper shank not being round or of the same taper exactly as the taper hole in the spindle, by this taper hole being out of line with the spindle, by looseness between the spindle and its bearings, etc. Each of these items is very small in any good milling machine; yet the accumulation of these little errors is sufficient to cause a mark and this mark needs to have a depth of only a fraction of a thousandth of an inch to be very plainly visible. As these marks are caused by conditions which return once for every revolution of the cutter,

it is plain that the spacing of the teeth can have no effect on the distance between them and, therefore, on the grade of finish.

To test this still further, two cutters of the same size exactly were placed side by side on an arbor. The cutters were ground together, so as to be sure they were of equal diameter, and they were ground on the arbor so as to be sure that the error would appear simultaneously for both cutters. A block of cast iron was finish-milled with these cutters in such a way that each cutter would sweep half the width of the block. The same number of marks appeared on both sides of the block, and these marks were exactly in line with each other, as might have been expected. The grade of finish was the same for both sides. It was neglected to mark the two sides of the casting to see which cutter was operating.

After this test all of the teeth but one of the two cutters were ground lower, so as to be out of action entirely, leaving only one tooth of the one cutter operative. Another cut like the first one was taken over the same block, and again the finish appeared the same on both sides. There was a difference of opinion between different observers as to which side was cut by the single tooth. By close observation, however, a difference could be detected when light fell on the work in a certain direction, under which conditions one side showed more gloss than the other. Straightness, flatness and smoothness to the touch were exactly the same for both sides, notwithstanding that one cutter had one tooth only and the other fourteen teeth. Though it is not recommended here to use cutters with one tooth only for finishing, the foregoing test shows plainly that there is no merit in fine spacing. Attention is again called to the fact, that even though the finish on a single piece *might* be better with more teeth in action, the *average* finish for an entire lot of pieces is better with less teeth.

In further pursuance of the subject the writer of the paper has the following comment to make which may cause some reflection:

However accurately a milling machine may be built, the spindle is not exactly at right angles with the table. The amount of variation from the right angle is very small in a properly built machine, but some variation exists. Besides, this variation is liable to become greater when the machine wears. The result is, that when feeding in one direction the leading teeth of the cutter dig deeper into the work, leaving the other side of the cutter entirely clear, but when feeding in the opposite direction the opposite takes place, which make the teeth drag over the work. In order to provide the teeth with clearance, the back end of the tooth is ground away at an angle of three to five degrees.

The paper included a number of diagrams showing the relative efficiency of different styles of mills for removing a given amount of metal.

As might be expected from the importance of the subject, it was accorded an animated discussion, and in the main the views of the author were agreed with. Mr. Parker believed that the cutter developed by Mr. De Leeuw possesses to a remarkable degree the valuable attribute of saving power, and in certain classes of work, such as heavy manufacturing milling, it will no doubt find a field to which its characteristics are most suited. In regard to the reduction of teeth in the new cutter, he said:

It is evident that the new cutter, having so few teeth, produces a hammering action on the work greater than that of the standard cutter, because there are not sufficient teeth in contact to steady the action; and, unless the machine has the rigidity and massiveness possessed by the heavier class of machines to withstand this pounding effect, the smooth action, so essential to good milling practice, is not obtained. This undesirable feature was very noticeable on a No. 2 Universal milling machine, which is essentially a tool-room machine and necessarily of a light character to enable it to be handled quickly and easily. The pounding was so severe that the tests had to be suddenly terminated, owing to the abusive action to which the machine was subjected. In another machine, somewhat heavier than the one referred to, work, when using the ordinary cutters, could be held in a vise clamped in the usual way; but, with the new cutters it would be pushed bodily out of the vise, and auxiliary means had to be provided to hold it in place. This would indicate that the new cutters would not be suitable for that class of work, when for some reason it could not be so firmly secured as desired, or when great care would have to be exercised in clamping down work to the fixture or machine table, to prevent springing.

A. F. Murray said that Mr. De Leeuw's experiments were in accord with the theories which he had been advocating for several years; and mentioned that at the Blake & Knowles Steam Pump Works they were continually re-cutting old milling cutters for the manufacturing departments and invariably reduce the number of teeth about half, setting the mill deep enough to cut out completely every other tooth. It is his opinion that saws, slotting and side mills, as ordinarily made, have too many teeth, and also that a large proportion of the success obtained by the use of inserted tooth mills has been due to the reduction in the number of teeth.

In concluding the discussion W. S. Huson agreed with the author in the following comment:

We get better results in surface milling from wide-spaced cutting edges than from the usual close-spaced. We have found in testing work milled with cutters having many teeth that when the cut was finished, say at 3 P. M., and tried with straight edge and gages, it was right, while the next morning it was out. There are two causes for this: the peening effect of the cutter, and another which I think is not fully considered, but which I believe is borne out by experience, namely, that the teeth of a milling cutter punch or force little particles of cutting dust into the interstices or pores of the iron, which finally respond to the force exerted on them, and throw the work out of alignment. A cutter with fewer cutting edges for surface milling does not give a bright finish, but the product requires less subsequent filing and fitting. It is for this reason that the question of milling cutters is paradoxical, for in the case of gear cutters with many cutting edges we get a smoother gear tooth, whereas in surface milling we get a truer surface with fewer edges. I agree with the paper that in surface milling the fewer cutting edges, the more chip clearance, and hence the more permanent, if not quite so smooth, work will give better final results than cutters with close-spaced edges. The amount of power consumed is of little importance in the final cost, if as a result of rapid machine output, manual labor must be used to make the work acceptable.

In all probability this valuable paper and the discussion accorded it will have a material bearing on the consideration of the best form of milling cutters, and any improvement in this line means, of course, a further increase in the range of work now possible with this important machine tool. As it stands now, the advantage of the milling machine over the planer lies very largely in its ability to produce, with reasonable accuracy, a large number of duplicate surfaces, the formed cutter and the removal of personal error in making of measurements by the operator being the factors that enable it to produce these results. After an operator, however, has become skilled in its use and thoroughly familiar with its every detail, he can appreciate the great capabilities of this class of machine tools.

SPECIAL FREIGHT CAR OF LARGE CAPACITY

Great difficulty has been experienced by the Westinghouse Electric & Mfg. Co. in obtaining cars that will permit the shipping of large transformers completely assembled. Although special cars have been arranged for this purpose a recent order of 15 transformers were too large in size and weight for any of the cars now in existence, and it was necessary to design and have built three cars with a depressed center giving the minimum distance from floor to rail and at the same time a carrying capacity of 150,000 lbs. concentrated in the center well. These cars were built by the Atlas Car & Mfg. Co., of Cleveland, the design being the combined product of the builders and owners, it also being submitted for approval to the Pennsylvania Railroad. They are entirely of steel, 35 ft. in length, and have a maximum capacity when loaded over the trucks as well as in the center of 205,000 lbs. The floor at the center is but 2 ft. 2 in. above the top of the rail, there being a clearance of 7 in. between the bottom of the sills and the rail.

As will be seen by reference to the detailed drawings, the construction of the car is very simple, consisting of four longitudinal girders, the center ones continuous between bolsters and the side ones continuous for the full length of the car. These longitudinals are connected and stiffened by numerous diaphragms and the bolster, which is of very heavy but simple construction.

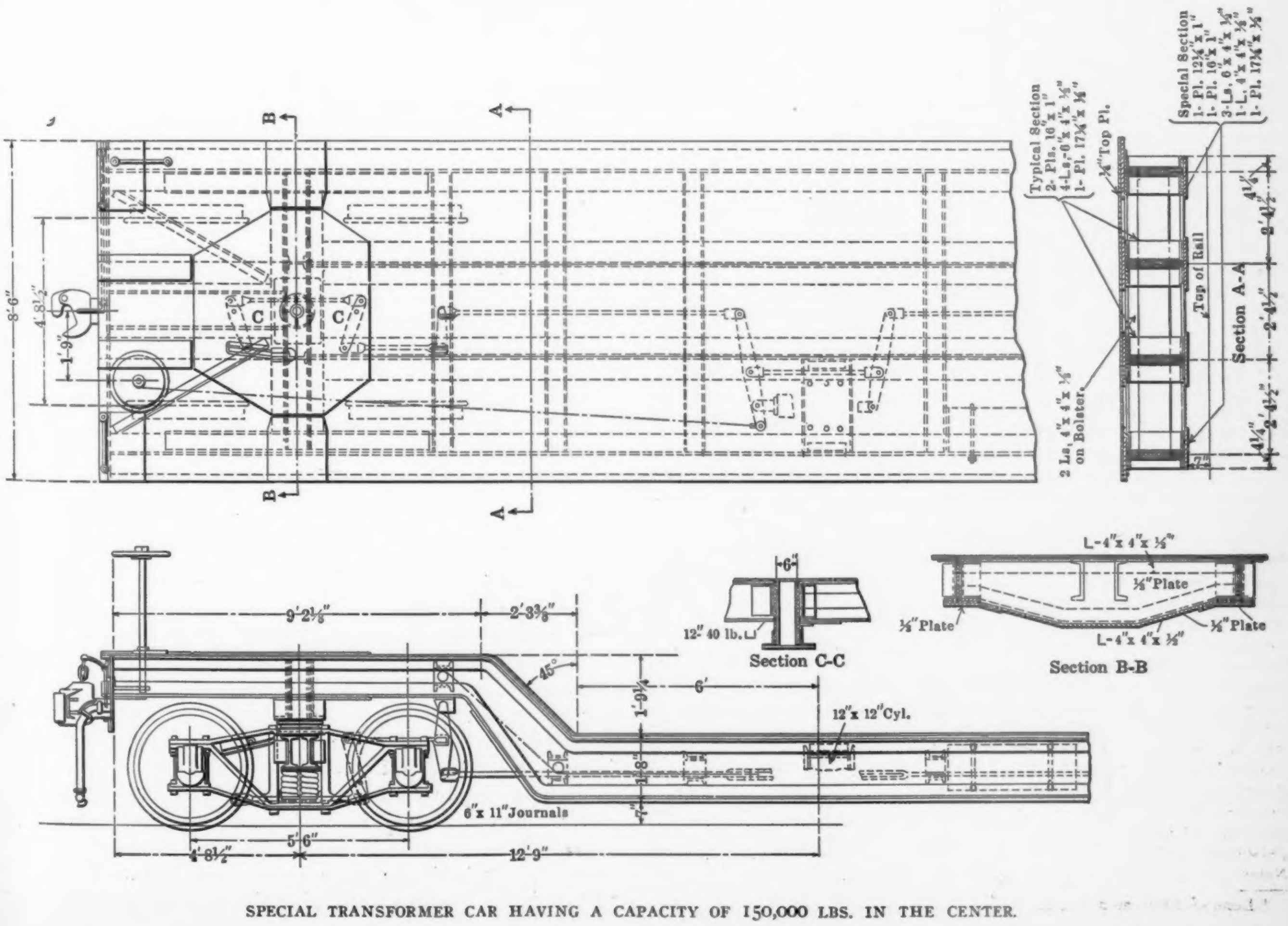
One-half inch plate is used in the web of all the longitudinals, being cut to the shape and size shown in the side elevation of the car. The two center girders have two $6 \times 4 \times \frac{1}{2}$ in. angles top and bottom, with a 16×1 in. top and bottom cover plate. These cover plates are carried continuous between bolsters at

the top rail and nearly to the top of the inclined section at the bottom. The side girders are the same with the exception that a 4 x 4 x ½ in. angle is substituted for one of the 6 x 4 x ½ in. angles at the bottom and the cover plate is but 12¼ in. wide on the bottom. The diaphragms are all ¼ in. plate with 4 x 3 x ⅜ in. angles and are located as shown in the illustration. At the bolster the construction consists of two ½ in. web plates formed to proper shape and spaced 6 in. apart and four 4 x 4 x ⅜ in. angles with a ½ in. cover plate at the bottom and a ¼ in. plate at the top. I-beam separators are framed vertically between the web plates at the connection with the center sills and extra heavy angles are used for connecting the bolsters with the continuous side sills. The end sill is formed of ½ in. plate with 4 x 3 x ⅜ in. angles, as shown. A ¼ in. plate covers the entire top of the car, having countersunk rivets wherever necessary.

STEEL CAR OF 205,000 LBS. CAPACITY.

Special trucks with 6 x 11 in. journals have been designed following the M. C. B. requirements in every particular. The wheels are 33 in. in diameter, of rolled steel, and weigh approximately 750 lbs. The total weight of the car is 53,000 lbs., and it is provided with Westinghouse type S. brake having a 12 x 12 in. cylinder. This will brake 85 per cent. of the light weight of the car with an 8 to 1 reduction.

RAPID GROWTH OF STEEL CARS.—According to authentic reports there were in use in this country on December 31, 1910, 54,609 passenger cars of which 2,927, or 5.3 per cent., were of all-steel construction. Besides the latter there were 1,481 or 2.7 per cent. built with steel underframes. The rapid growth of the all-steel passenger equipment is best understood when it is known that of the 2,000 passenger cars ordered in 1909, about 24 per cent. were of steel construction and 21 per cent. were built with steel underframes, and in 1910 there were 3,783 new cars acquired, of which 63 per cent. were all steel and 14 per cent. were of steel underframe construction. This shows a rapid growth in sentiment for the steel car. This fact is emphasized by the statistics which show that at the close of 1908 only four-fifths of one per cent. of all the passenger equipment was of all-steel construction.



SPECIAL TRANSFORMER CAR HAVING A CAPACITY OF 150,000 LBS. IN THE CENTER.